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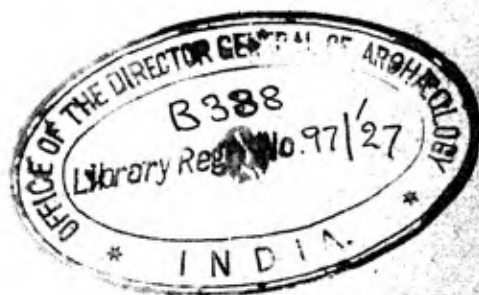
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IRON IN ANTIQUITY.



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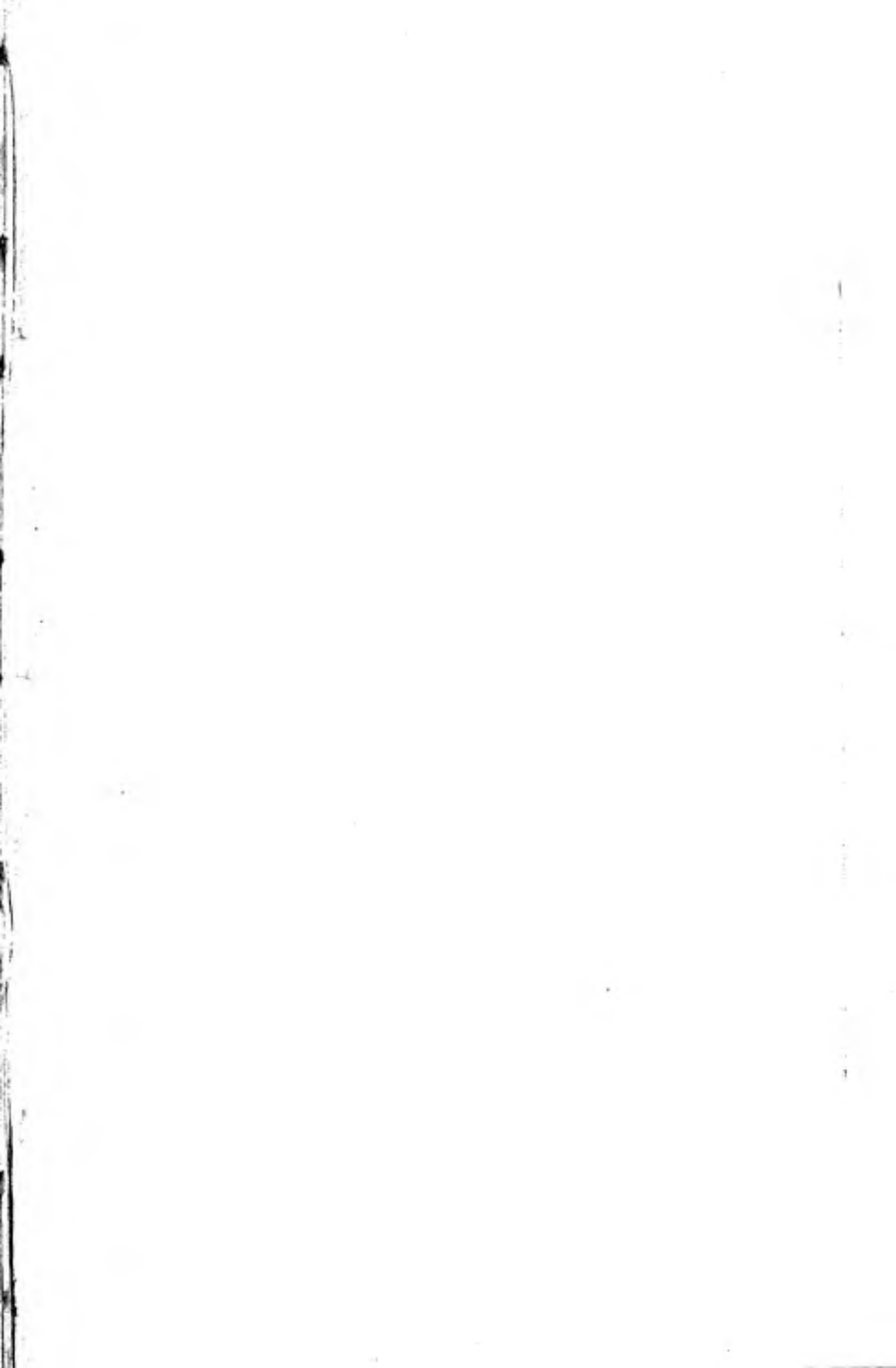
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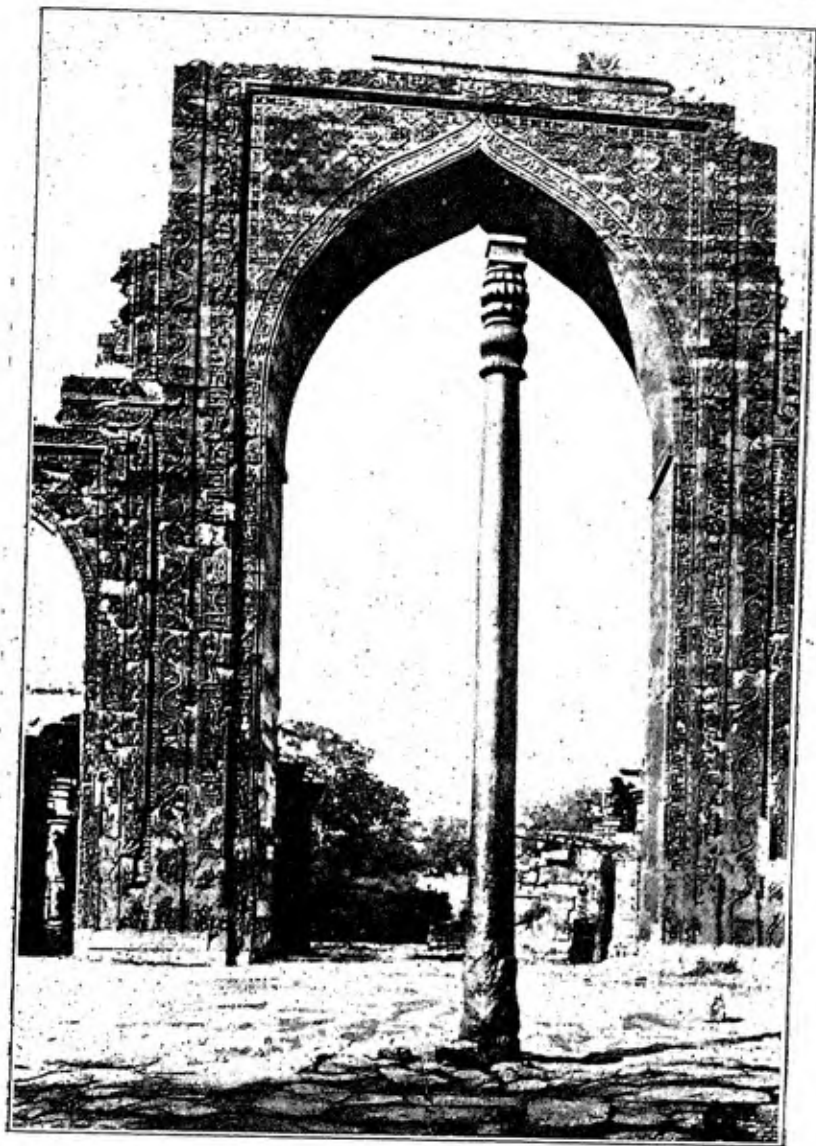
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IRON IN ANTIQUITY.

BY

J. NEWTON FRIEND,
D.Sc., Ph.D., F.I.C.

With Frontispiece and Sixteen Other Illustrations.

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PREFACE.

IRON is so closely interwoven with the economic life of the various nations of the earth that a careful study of its history is one of unusual interest.

In attempting to give an account of Iron in Antiquity, however, we are immediately confronted with a serious difficulty. References to Iron occur in literature of all kinds. They appear alike in Archæological and Metallurgical Works ; in books on Travel, Language, History, Religion and Romance ; amongst the ancient Sagas and in local traditions. Indeed, where may they not be found ?

The task of collecting all these together, of classifying and arranging them would be stupendous, and absorb the energies of one man for more than a life-time. No attempt has been made, therefore, to render this little work exhaustive. It has been the aim of the Author to lay before the reader an account of such portions of the early history of iron as seem of particular interest and value, without unduly burdening the story with duplication or masses of detail.

At the same time the needs of the earnest Student have not been forgotten, and numerous references are given to the sources from which the information in the text has been derived.

The Author's thanks are due to the Council and to the Secretary, Mr. G. C. Lloyd, of the Iron and Steel Institute, to make full use of the Author's Carnegie Scholarship Memoir for 1923, entitled "Iron in Antiquity," in the preparation of this work, and for permission to reproduce the figures contained therein.

It is believed that all other acknowledgments appear at appropriate places in the Text.

J. NEWTON FRIEND.

MUNICIPAL TECHNICAL SCHOOL,

BIRMINGHAM,

March, 1926.

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IRON IN ANTIQUITY.

CHAPTER I.

INTRODUCTORY.

OWING to the unprecedented importance of iron in its relation to modern civilisation the early history of the metal possesses peculiar fascination for the antiquary. It is safe to assert that the wonderful progress which has marked our path during the last 100 years would not have been possible had not the earth possessed an abundant supply of iron ore. In whichever direction we cast our eyes, articles of iron, large and small, essential and ornamental, meet our gaze. It is iron* in some form or other that constitutes the essential framework both of our railways and of our mercantile marine. Without these rapid means of transport the huge populations of London and our larger cities could not be fed and supplied with the necessaries of civilised life as we know it to-day. Again, reinforced concrete owes what strength and adaptability it possesses almost entirely to its iron frame, and as our supplies of building stone become depleted, we shall have to rely more and more upon this material. Indeed, of all the metals with which this world is stocked, iron takes the foremost place in the service of man.

There is a peculiar fascination in tracing the history of men and things through bygone ages. The more educated we become the greater is our desire to learn about our

* Using the word *iron* in its widest sense to include the cast or wrought metal and steel.

progenitors, how they lived and what manner of men they were. It is but a century ago that practically nothing was known about former ages other than that recorded by ancient writers. Indeed, Dr. Johnson is reported* to have said that "All that is really *known* of the ancient state of Britain is contained in a few pages. We *can* know no more than what the old writers have told us."

Whilst certain branches of study have been pursued by man for countless years, as witness Astronomy, Alchemy and Witchcraft, the systematic Study of Antiquities is of relatively modern growth. This, in part, is due to religious conservatism. Christendom believed—and had always believed—that the world was but a few thousand years old, and that since the Creation the deluge was the only great catastrophe by which considerable change had been wrought on the Earth's surface. "Never," said Lyell, "did a theoretical fallacy, in any branch of science, interfere more seriously with accurate observation and the systematic classification of facts."†

So long as these views were held there seemed but little encouragement or scope for antiquarian research. The attention of scientists was therefore in the main directed into other channels. Fortunately, however, both the astronomer and the geologist came eventually to realise that 6,000 years are but as a day in the history of the universe in general and of the world in particular. They suggested provisionally a minimum of about 100 million years for our solar system. Although this may yet prove to be far too short a time, once these views became accepted, the antiquary could claim a longer lease of life for man, and there was thus opened out before him an enormous field for research fraught with possibilities

* Boswell, "Life of Samuel Johnson," chap. xl.

† Lyell was born in 1797; died Feb. 22, 1875.

hitherto undreamed of. No longer was man's antiquity limited to 6,000 years minus six days; his history might conceivably extend through a period of several hundred thousand years.

Recent advances in physics have lent strong support to the view that the world cannot be less than 100 million years old. It is known that the element uranium is undergoing gradual disintegration into many products, two of which are the gas helium and metallic lead. The rate of decay of the uranium has also been measured. Hence by determining the relative proportion of helium to uranium in minerals, it is possible to calculate, on the assumption that no helium has been lost, the length of time required to produce that quantity of helium—in other words, the age of the mineral is arrived at. Owing to the fact that some of the helium will undoubtedly have diffused away, the estimate gives a *minimum* value for the required age. Similarly, a determination of the uranium-lead ratio, owing to the permanent and non-volatile character of the latter metal, enables a *maximum* value for the age of the mineral to be estimated. The true value, therefore, lies somewhere midway between these two extremes. Assuming now that such minerals are of the same ages as the geological strata in which they lie, the ages of these latter are readily determined. Some of the data obtained in this way are given in the table on p. 4.

Although it is now generally conceded that man has ascended from the lower animals, there is considerable diversity of opinion as to the time when the branching off took place. Gregory* places it in post-mid-miocene times, which would make it, according to his computation, close upon one million years ago, or, according to radio-

* W. K. Gregory, "The Origin and Evolution of the Human Dentition" (Baltimore, 1922).

AGE OF THE ROCKS IN MILLIONS OF YEARS.*

Geological Period.	Minimum Value. From Helium-Uranium Ratio.	Maximum Value. From Lead- Uranium Ratio.
Pleistocene,	0.1 to 1	...
Pliocene,	2.5	...
Miocene,	6.3	...
Carboniferous,	147	340
Precambrian,	141 to 622	1,025 to 1,640

active data, not less than three million years ago, but probably longer. Keith† considers it must have happened in pre-miocene times, that is appreciably longer still. In either case the field is sufficiently large to keep the antiquary busy!

Obviously in those far-off days there was no written word, as we understand it. All hope of finding contemporary manuscripts is thus out of the question, for these could only be produced after man, through unrecorded ages of toil, had progressed upwards to a relatively high state of civilisation. Nevertheless, several methods are open to us by which glimpses can be obtained of the way in which primitive man lived.

1. First there is the application of pure reason or philosophy to the problem. This was the accepted method of the Greeks, and is beautifully exemplified by the writings of Lucretius‡ *circa* 56 B.C., to which further reference is made later. It may so happen that the foregoing method is, in certain cases, the only one by which pictures of the past can be obtained. It was

* Data taken from Burr, "The Alkaline Earth Metals." Volume iii., Part I. of Friend's "Textbook of Inorganic Chemistry" (Griffin, 1925).

† A. Keith, *Nature*, 1922, vol. cx., p. 835.

‡ Lucretius, *De Rerum Natura*, translated by Munro (Routledge). Lucretius died about 52 or 51 B.C.

practically the only avenue open to Lucretius, yet later researches have tended to show that his conjectures are surprisingly near the mark.

2. In many cases, however, philosophy may be supplemented, checked, and corrected by a study of modern savage life, or of records chronicled by observant travellers in uncivilised lands. This is abundantly illustrated in the sequel.

3. By far the most beautiful and conclusive evidence is, however, to be found in the earth itself. Around us and beneath us lie traces of man's handiwork in such various forms as implements, paintings, carvings, and the like. These the antiquary skilfully pieces together, and every year sees, unfolded to our wondering eyes, some new detail in the fascinating story of man's childhood.

It is one of those pleasing ironies with which the history of science abounds that, at the very time when Dr. Johnson declared the impossibility of learning more about primitive man, there was lying in the Sloane Museum a rudely-chipped flint weapon which had been found, at the end of the seventeenth century, associated with an elephant's tooth, 'opposite to black Mary's near Grayes inn lane,' in which street Johnson once lived.* The language was there, but the interpreter was wanting.

By dint of persistent application of the foregoing methods of study the antiquary has been able to portray, with an astonishing wealth of detail, the story of the life of our primitive ancestry. Only the briefest sketch of this can be attempted in these pages.

The Age of Stone.

In those far-off times when man was hardly to be differentiated from the brute creation his weapons would

* Clodd, "The Story of Primitive Man" (Newnes, 1897), pp. 9-10.

be natural objects just as nature formed them; the trees, the forests, and the caves would form his home. As Lucretius * says, when speaking of primeval man, "Arms of old were hands, nails and teeth, and stones and boughs broken off from the forests. . . . Trusting to the marvellous powers of their hands and feet they would pursue the forest-haunting races of wild beasts with showers of stones and clubs of ponderous weight; and many they would conquer, a few they would avoid in hiding places."

Bitter experience would gradually teach them to prepare beforehand their weapons and keep them in readiness for all emergencies, just as David, prior to his encounter with Goliath hundreds of thousands of years later,† "chose him five smooth stones out of the brook, and put them in the shepherd's bag which he had, even in his scrip."

At first the weapons of primitive man would be extremely crude; so rough and shapeless that the modern antiquary may well doubt if they have ever been used by human hands. Such stones are termed *eoliths*, from the Greek *eos*, dawn, and *lithos*, stone. But it would soon be observed that, other things equal, the most successful hunter and warrior was he who had the finest weapons. Increasing attention would therefore be paid to the shaping of the implements, which would now begin to bear such obvious signs of skilled workmanship that no longer is the antiquary in doubt as to their human origin. They are known as *paleoliths*, from the Greek *palaïos*, ancient, and are usually of flint, which is particularly amenable to chipping, although other stones were sometimes used. The coarse, rude flaking of the earlier specimens was gradually improved upon, and ultimately tools

* Lucretius, *opus cit.*, Book V.

† 1 Sam. xvii. 40, R.V.

and weapons were produced exhibiting exquisite workmanship. These are known as *neoliths*, from the Greek *neos*, new. Some of the very finest specimens have been found in Egypt and date back to a little before the First Dynasty—that is *circa* 4,000 B.C.* The cutting edges have been produced by such fine chipping, involving thousands of minute flakings, that at first glance they appear to have been ground perfectly straight like a modern knife edge. It is not until they are more closely examined that their true serrated nature is apparent. Such implements must have taken a very long time to make and, being too valuable for ordinary use, were probably reserved for religious ceremonial, just as, at the present day, choice tapestry and needlework are consecrated to the churches. According to King and Hall † the Egyptian specimens referred to are “undoubtedly the most remarkable stone weapons ever made in the world.”

Flint was not the only material used by neolithic man; implements in other stones such as quartzite and even in minerals such as Cumberland red hæmatite or Kidney ore have been found. Nor were the implements always chipped. Frequently they were ground to a smooth cutting edge. Some of the knives were curved like a pruning hook or sabre, whilst the winged arrows and spear-heads were produced with magnificent symmetry.

The most common form of neolithic implement is the axehead, or *celt*—a word possibly derived from the Latin *celtis*, chisel. They were known to both Greeks and Romans as “thunderbolts”; the Germans and Scandinavians term them “Thor’s Hammers.” In Britain and Ireland many country folk look upon flint arrow-heads

* See the chronological Table, p. 160.

† King and Hall, “Egypt and Western Asia in the Light of Recent Discoveries” (S.P.C.K.), 1907, p. 14.

as weapons shot by elves, whence the name *elf-stone*, or *elf-shot*. Mounted in silver, they are a sure safeguard against poison and the evil eye.*

Native Metals.

The question naturally arises as to whether or not primitive man ever made use of native metals. There is every reason to believe that he did. At a very early age gold was most certainly known to him, and prized on account of its intrinsic beauty and resistance to tarnish. He was also familiar with native copper and perhaps with other metals as well, such as silver, iron, or indeed, any metal that might perchance occur in a native state. This does not mean that he necessarily realised the connection between the metals and the ores around him. Rather would he regard the metal as a particularly useful kind of stone. He would be struck by the fact that the "stone" did not chip or crack upon being hammered; on the contrary, it would yield to the strokes and could be cold worked into simple shapes for ornament or for personal use. Native copper, in particular, he would prize. Possessed of great tenacity, and yielding a fine hard edge when rubbed or ground, some of his most valued implements would be made of that metal. On account of its comparative rarity and unique properties, he would be inclined to receive it as a gift from the gods and ascribe to it divine powers.†

We are led to these conclusions from a study of savage life within historic times. To quote a familiar example,

* Clodd, *op. cit.*, p. 99.

† This idea receives support from the attitude of semi-civilised peoples towards metals within historic times. An apt example is afforded by the superstitious reverence accorded to Gunnar's famous bill (or battle-axe) in the Icelandic saga times (see p. 109).

within the environs of Lake Superior, in the U.S.A., large masses of native copper occur, and there have here been unearthed at various times numerous axes, lance-heads, and other primitive implements composed of this metal, all shaped by hammering. The Indians of the North Pacific Coast had learned to utilise the deposits of native copper in the Chilcat country, north of Sitka, on the isle of Baranof, and the copper shields made by them travelled down the coast to Queen Charlotte's Island.*

But if native copper was used by primitive man, does it necessarily follow that native iron was also utilised by him? Upon this point there has been a conflict of opinion. It is generally accepted that the bulk of native iron is meteoric and not telluric in origin. Some have urged that the amount of this meteoric iron is so small,† and the chance that primitive man would come across it is so remote, that it may be left out of consideration. Zimmer,‡ however, in a masterly analysis of the subject, has finally disposed of that idea. He shows that a minimum of 246 tons of meteoric iron is known to science at the present time, and in prehistoric times there were all the accumulations of previous ages for primitive man to draw upon. Hence it is reasonable to suppose that meteoric iron must have been considerably more abundant than now, particularly when it is remembered that, in consequence of its nickel content, celestial iron has a much longer life than telluric iron, because of its enhanced resistance to corrosion. Further, as Zimmer points out, "it is certainly a fact that fewer iron meteorites are

* Ridgeway, "The Early Age of Greece" (Clay & Sons), 1901, vol. i., p. 595.

† See Gowland, "Huxley Memorial Lecture for 1912," Royal Anthropological Institute of Great Britain and Ireland.

‡ Zimmer, *Journal of the Iron and Steel Institute*, 1916, No. II., p. 306.

found in the Old World than in the New, which is an argument in favour of the use of meteoric iron by primitive people. The Old World having as a whole the older civilisation, the meteoric iron was used up by the ancients, while in the New World it has accumulated and is now being found." Indeed, "it is not to be wondered that the meteorites are more frequently found in America, for those which have fallen in the Eastern Hemisphere have been turned to some uses, often fantastic, centuries ago. They have been forged into weapons with magical attributes, set up as idols, pounded for medicine, and worn as amulets."*

Again, the view has been taken that meteoric iron is too brittle to be cold-worked in primitive fashion. This implies that only the telluric metal was available to man prior to the iron age, and, as has been mentioned, the supplies of native telluric iron are in general exceedingly small. Petrie† has fallen into this error; nevertheless he agrees that long before iron was recognised as a metal, at any rate in so far as the Egyptians were concerned, implements of this material were not unknown. He assumes that the metal had been found native, or else produced casually by accident. Meteoric iron, however, is not usually brittle.‡ Zimmer estimates that only 1 per cent. of the meteoric metal known to science is brittle, leaving 99 per cent. available to man for cold working.

This much is clear, therefore. There was sufficient malleable meteoric iron on the earth to supply primitive man with an appreciable number of implements. The question now arises as to whether or not primitive man

* A. Harvey. Quoted by Zimmer, *loc. cit.*, p. 348.

† Petrie, "Ancient Egypt," 1915, Part I., p. 12.

Gowland, *opus cit.*, p. 277.

was sufficiently intelligent to make use of it. The answer to this is probably in the affirmative. Many of the large meteorites are of such irregular shape that it would not be impossible for primitive peoples, even with flint tools, to sever some of the protuberances. The Otumpa meteorite (Argentina), the original weight of which was probably about 15,000 kilogrammes, shows no fewer than six places from which portions have been removed. The Descubridora meteorite (Mexico), which weighed about 575 kilogrammes, has a gap 9 centimetres long in which is wedged a broken copper chisel left by some primitive workman.

“ Meteoric iron was cut by the ancients in the same way as they cut pieces off the large masses of native copper found on the banks of Lake Superior. A block of such copper which was found in 1875 on the territory of the Minong Mining Company (Isle Royale, Lake Superior), 16 feet 6 inches below the ground in ancient workings and which weighed 5,720 lbs., showed definitely the marks of primitive tools where portions have been severed. A piece which had been so detached in antiquity has been found in Ohio, hundreds of miles from the main mass. A similar mass of copper in the Minnesota mine, near the Ontonagon River, also in ancient workings and 18 feet below the surface, weighing 6 tons, had been nibbled all round by the Stone Age man.

“ It is of course not suggested that iron can be cut as readily as copper, but the following incident, showing how primitive man, with the simplest tools and patience, can cut up heavy masses of iron, happened in 1727 after Roggweeen had lost one of his ships on one of the South Sea Islands. The natives collected all the iron from the wreck eagerly, lifted the anchors from the sea in the harbour of Tahiti, cut them up, and the King of Tahiti

sent a piece of one of the anchors as a rare present to the King Opuni of Borabora.”*

Again, as regards small meteorites, or tiny pieces of native metal of telluric origin, these might be worked up as beads or other ornaments. Probably this was the origin of the metal beads, the oxidised remains of which have been found in pre-dynastic tombs in Egypt, dating back, in all probability, some 4,000 B.C.†

A study of primitive life within historic times is here, however, of considerable help. Numerous records are extant of travellers who have found rude peoples using iron implements which they could not have obtained either by barter or by metallurgy. According to Zimmer,‡ when in 1721 Hans Egede found the Eskimos using arrows, spears, &c., with bone and stone points, he also found them occasionally tipped with iron points. Hearne§ in 1772 visited an Eskimo tribe on the Coppermine River and observed that whilst they were as a general rule using weapons and implements of native copper, they also possessed a few which were evidently of meteoric iron. He described two pieces, one $1\frac{3}{8}$ inch by $3\frac{1}{2}$ inches, converted into a knife as used by a woman, and the other, 1 inch by $2\frac{3}{8}$ inches, which was mounted on a piece of walrus tusk and used as a man's knife. Further, Sabine, who accompanied Ross in 1818, reported that the Eskimos of Cape York in Baffin Bay, on the west coast of Greenland, employed meteoric iron in a similar manner, the members of the expedition being particularly attracted by the knives they used. He stated that every one of the Eskimos who visited them on and after August 10, 1818,

* Zimmer, *opus cit.*, pp. 337-8.

† See p. 159.

‡ Zimmer, *loc. cit.*, p. 308. See also Ross, “A Voyage of Discovery to Baffin's Bay” (1819), p. 114.

§ Hearne, *Reisen nach dem nordlichen Weltmeer*, 1797, p. 118.

carried an implement with an iron edge which served as a knife. The handle was from 9 to 11 inches long, being made of flat bone, whilst the cutting edge was formed by a series of from three to seven flattened flakes of iron inserted into a groove in this bone, extending to about half its length. "It transpired that the source of the iron was the three masses of the Melville Bay meteorite, and that the pieces detached were beaten flat between stones without heat. One of the masses, known as 'The Woman,' was softer than the other two, and was, therefore, almost exclusively used. It is estimated that nearly one-half of the original mass has been detached by the Eskimos through many generations, about 12 cubic feet being left."

From the foregoing the assumption appears by no means unreasonable that primitive man, even when still in the stone age, could and did make use of native iron, whether meteoric or telluric, in fashioning some of his most valued tools and weapons. If that is the case, why are iron tools not found in stone age burials? The obvious explanation is that the metal would quickly rust and all trace of it would rapidly disappear. As is so often the case, however, further consideration shows that "the obvious" cannot be correct. Petrie* is undoubtedly near the truth when he says, "The supposition often put forward that iron might entirely disappear in course of time is a mere fallacy. When buried in earth iron rusts much more slowly than if exposed to air, and in many situations it is remarkably preserved. When it has at last turned to rust, it has become a material which can never disappear.† A lump of oxide of iron is practically insoluble when buried, and its strong colour and staining power make it very obvious. To remove all trace of it when buried

* Petrie, "Ancient Egypt," 1915, Part I. p. 20.

† Ordinary conditions are of course assumed.—J. N. F.

would be impossible within the human period by any conditions." Although this last sentence appears to the present writer somewhat too liberal, in the main the foregoing argument is undoubtedly correct.

Zimmer* suggests that the iron implements "were much too valuable to be buried with the dead, and not likely to be left behind by careless owners"—hence their scarcity in museums. This is indirectly supported by modern savage life. Livingstone† mentions an interesting case of a native of the central regions of Southern Africa whom he met during his travels. The man had a bow about 6 feet long and iron-headed arrows about 30 inches in length. These he prized greatly, for he had a store of wooden arrows also, neatly barbed, to shoot in cases where he might not be quite certain of recovering them.

* Zimmer, *loc. cit.*, p. 303.

† Livingstone, "Missionary Travels" (Ward, Lock), p. 235.

CHAPTER II.

THE AGE OF METALS.

ALTHOUGH, as has been shown, there is every reason to believe that primeval man was, in certain districts, more or less familiar with one or two of the more common native metals, he was still struggling in the throes of what the antiquary has termed the stone age. It was not until he had learned to prepare metals, notably copper or its bronze alloys, direct from their ores that he passed into the so-called "age of metals."

Authorities are divided on the question as to whether metals were discovered independently by different peoples or by one people, who transmitted the knowledge to surrounding tribes and these in turn to yet others. To this latter school belongs Professor Elliot Smith, who attributes the discovery of copper to the Egyptians, and maintains that all other nations learned the art of smelting the metal either directly or indirectly from them. Those who believe in the multiple source theory, however, direct attention to the fact that, in so far as Britain is concerned, the earliest metal implements do not resemble those found in Eastern lands, whence the metal culture is supposed to have sprung. Now, "had these things been imported, they would inevitably have conformed to the types manufactured in those places; and, as inevitably, would have influenced the forms of our earliest native work. In like manner, had foreign craftsmen brought the knowledge hither, they would have worked

at first on the lines of old habit, and the work of their hands would thus have betrayed the place whence they had come.”*

The precise manner in which the metals were first discovered is, of course, unknown. Possibly, as Lucretius said, “fire had burnt up vast forests on the large mountains, either by a discharge of heaven’s lightning, or else because men waging with one another a forest war had carried fire among the enemy to strike terror, or because drawn on by the goodness of the soil they would wish to clear rich fields and bring the country into pasture, or else to destroy wild beasts and enrich themselves with the booty. . . . Whatever the fact is, from whatever cause the heat of flame had swallowed up the forests with a frightful crackling from their very roots and had thoroughly baked the earth with fire, there would run from the boiling veins and collect into the hollows of the ground a stream of silver and gold, as well as of copper and lead. And when they saw these afterwards cool into lumps and glitter on the earth with a brilliant gleam, they would lift them up attracted by the bright and polished lustre, and they would see them to be moulded in a shape the same as the outline of the cavities in which each lay.” Thus would be aroused the curiosity and interest of primeval man, and his attempts to convert the metals into implements would render him familiar with many of their peculiar properties.

Gowland,† however, considers that the discovery of metals “was brought about in a more commonplace and more humble way. It had its origin in the domestic fires of the Neolithic Age.

“The extraction of the common metals from their ores

* See Ault, “Life in Ancient Britain” (Longmans, 1920), p. 113.

† Gowland, *Journal of the Institute of Metals*, 1912, vii., 24.

does not require the elaborate furnaces and complicated processes of our own days, as pieces of ore either copper carbonate or oxide, cassiterite, cerussite, or mixtures of these, and even iron oxides which by chance formed part of the ring of stones enclosing the domestic fire, and which became accidentally embedded in its embers, would become reduced to metal. The camp fire was, in fact, the first metallurgical furnace, and from it, by successive modifications, the huge furnaces of the present day have been gradually evolved."

Ault* has developed Gowland's view in a singularly interesting and picturesque manner. He depicts a craftsman "who perchance having business in a distant village is benighted on his way thither, and so has to pitch his camp in a strange place for the night. He gathers together some scattered fragments of rock for his hearth-stones, kindles a fire on them, and cooks his evening meal. Ere he sleeps, he builds high the fire for protection in the dark hours, and ever again rises and tends it until the morning. Then, while grilling some meat on the still glowing embers, he accidentally drops his flint knife into the fire. With a stick he quickly rakes out the precious tool, and stooping thus he pauses motionless, his gaze attracted and held by something gleaming ruddy-yellow among the scattered ashes. We, perhaps, should recognise it as copper, and with much thought may have guessed the cause of its appearance there. But he could not know that the hearth-stones chanced to be fragments of an outcrop of rich copper ore. . . . He stretches out his hand involuntarily to the glittering stuff, but the heat warns him in time, and he waits until it is cool enough to be examined, and meanwhile breaks his fast. Then in the endeavour to detach it from the mass of ore he finds

* Ault, *opus cit.*, p. 115.

he must use his stone axe, and so discovers its nature to be the same as that other extraordinary substance, found in a stream years ago by a fellow craftsman. And thrusting into his wallet this scrap of smelted copper with bits of ore still adhering to it, he goes on his way pondering deeply. On his homeward journey, full of curiosity, he camps again in the same spot, and his eager scrutiny next morning reveals the same result; and so with other fragments of metal he returns home. Soon his knowledge would begin to spread about that this strange stuff could be obtained at will in such and such a place by merely lighting fires on the ground there. Following this would come the recognition of the ore from non-metallic rock" and thus, in course of time man became possessed of an appreciable metallurgical skill.

A happy picture, probably true in substance, though the details may vary.

Another very pretty modification of Gowland's theory has been applied by Professor Elliot Smith to the discovery of metallic copper by the Egyptians. He directs* attention to the fact that long before the discovery of copper, its natural carbonate, known to us as *malachite*, from the Greek *malakhē*, mallow, was largely used by the pre-dynastic Egyptians, some 4000 B.C. as a pigment. Its green colour was compared to the Green Nile, which made the land of Egypt green and fertile. Hence magical virtues were attributed to it, and it came to be regarded as a prolonger of life. What wonder, then, that the women folk seized upon it as a valuable cosmetic and daily used it in preparing their toilet. "It is probable," writes the

* Elliot Smith, "The Ancient Egyptians and the Origin of Civilization" (Harper, 1923), pp. 10-12. See also Breasted, "Ancient Times" (Ginn & Co., 1916), pp. 47-48.

Professor, "that such circumstances as these were the predisposing factors in the accidental discovery of the metal." A fragment of malachite, or the cosmetic paste prepared from it, dropped by chance into a charcoal fire, would provide the bead of metallic copper and the germ of the idea that began to transform the world more than sixty centuries ago.

Charles Lamb's famous story of the discovery of the virtues of roast pork, which for the sake of greater piquancy he attributed to the Chinese, might be transformed, with only comparatively slight modifications, into an imaginary picture of the discovery of copper by some Proto-Egyptian woman, as the result of some similar domestic tragedy. Lamb showed a true insight into the working of the mind of primitive man when he represented him burning his house every time he wanted roast pork for dinner, simply because he first obtained that delicacy by the accidental burning of his house, in which the pigs were incarcerated. By an analogous mental operation, when the Proto-Egyptian began to realise the use to which copper might be put for the manufacture of implements, he began to make them in the exact semblance of his stone weapons and tools.

But even this he did not attempt for many years after he discovered copper. It appealed to him at first as a substance resembling gold, with which he was already familiar, and he employed it for making bands, possibly used for personal ornaments. He soon learned to make small pieces of wire, which, when bent into a loop at one end, became needles. Then came the later stage of manufacturing tools and implements in imitation of the flints he had been using up till this time. But it was not until many years, perhaps even centuries, later, that he

learned to cast the metal in moulds and make large blades—implements of the crafts, the chase, and warfare.

Admitted, then, that the earliest furnace was the ordinary domestic fire, it may be assumed that various modifications would gradually be introduced in order to render it more suitable and efficient. Gowland suggests that a shallow cavity would first be formed in the hearth of the fire for the reception of the molten metal, and this would be made larger as time went on and larger quantities of metal were required, by either deepening it or by surrounding it with a higher wall of stones. Furnaces of precisely this primitive form survived in Derbyshire up to the seventeenth century. In Japan the furnace for smelting copper, tin, and lead ores, was merely a hole in the ground, and was in universal use up to 1858, and is still* extensively employed. It is thus as simple and rude as that of the men of the bronze age.

What the particular metal or mixture of metals discovered in this way might be depended upon circumstances. Usually copper, or an alloy of this metal with tin, antimony, arsenic or nickel, was produced according to the nature of the ore employed. Thus, in Hungary, where the copper ores are associated with those of antimony, the early implements consist of an alloy of copper containing up to 4.5 per cent. of antimony. Similarly implements from Egypt sometimes contain 4 per cent. of arsenic, whilst those from Germany have from 2 to 4 per cent of nickel.† In Cornwall, where copper and tin ores are found together, the earliest metal implements consist of what may be termed a "natural bronze." In Ireland, on the other hand, owing to the fact that neither ores of

* i.e., 1912.

† Gowland, "Huxley Memorial Lecture for 1912," Royal Anthropological Institute.

tin nor those of copper containing tin were discovered in early times, the first Irish metallic implements were made of a more or less impure copper.

Similarly, in Cyprus as also in Egypt, implements of copper were used before those of bronze. They thus passed through what is known as the *chalcolithic age*, an intermediary stage of culture between those of stone and bronze.

Although this stage of culture is usually designated as the "copper" or "bronze" age, according to circumstances, it must not be supposed that copper or its alloys constituted the only metal known. As has already been indicated, even during the stone ages, some metals were known. In different districts, gold, silver, lead, tin, and even iron have been known from very early times; particularly the gold, which, on account of its incorrodibility and occurrence in the native condition, has been known from time immemorial. Within the ruins of the second ancient city of Troy, which Schliemann erroneously concluded to be the Homeric city, but which is now known to have been several centuries earlier still and probably dates back to *circa* 2200 B.C., numerous interesting metallic remains were found. In addition to vessels and ornaments in silver and gold, there were found weapons of copper and a hideous idol of metallic lead, evidently representing some ancient goddess.*

Again, excavations in the pre-dynastic Egyptian cemetery at El Gerzeh led to the discovery of a string of beads made of gold, iron, and carnelian (see p. 159). The iron had completely oxidised to rust. Evidently, therefore, this metal was known to the Egyptians some 4000 B.C. Lead was well known to the Sumerians and probably to the ancient Egyptians also,

* Cotterill, "Ancient Greece" (Harrap & Co., 1913).

since they knew of silver at a very early date. Both silver and lead probably reached them from Asia Minor.

The discovery of copper or bronze was one of the real epoch-making events of human history and led to developments of far-reaching importance, as indicated below (p. 23). Elliot Smith* dismisses as improbable the suggestion of the simultaneous discovery of copper in different parts of the world and attributes it entirely to the Egyptians. This appears to the present writer to be an unnecessary limitation; but whether we accept it in its entirety or not, the fact remains that a rapid extension of civilisation, coupled with remarkable migrations of peoples, coincided with the discovery of copper. Elliot Smith regards these as largely due to that discovery. Knowledge of metals gave the bronze age men decisive advantage in battle and thus developed a courage, born of security or a sense of superiority, which, coupled with a desire to find new sources of the metal, was one of the causes leading to the exploitation of new lands.

In so far as Egypt was concerned, one of the first effects appears to have been the union of the Northern and Southern Kingdoms under one king, Narmer or Menes, *circa* B.C. 3500, and thus commenced the series of Dynasties which figured so prominently in the history of the Near East. This was followed by an extension of Egyptian influence into foreign lands. Thus, the Sinaitic Peninsular was exploited in the First Dynasty for copper, and before the close of the Third Dynasty, *circa* B.C. 3100, the Egyptians were trading with Palestine as far north as the Mountains of Lebanon. In due course the knowledge of copper reached other peoples more remote from Egypt and these carried the tidings yet further afield, as mining camps for

* Elliot Smith, "The Ancient Egyptians and the Origin of Civilisation" (Harper, 1923).

working the metals spread from country to country, and the desire for conquest, inflamed with success, led to the migration of peoples. A wide dissemination of bronze age culture thus ensued.

Not only was the new civilisation thus rapidly scattered broadcast into other lands, but it developed with great vigour within its own realm. "The newly acquired mastery over the hardest materials, which the invention of metal tools secured, stimulated the Egyptian craftsman in the display of his abilities. In his zeal he simply ran riot in stone. He created the vastest monuments the world has ever seen; and alongside his Pyramids he built temples consisting of colossal blocks of granite, limestone, and other materials. The sculptors of Khephren's time carved out of the solid rock, upon the eastern side of his Pyramid at Gizeh, a gigantic representation of the head of the king himself on the body of a lion . . . and so created the Sphinx, which has been one of the wonders of the world for forty-six centuries."* Elliot Smith then goes on to point out that "Megalithic Monuments in other countries do not, as is commonly supposed, represent the really early stages in the art of building, but attempts on the part of less cultured people to imitate the finished products of the Pyramid age in Egypt. The latter were constructed after metal implements were invented; but people in foreign lands who had not yet learned to make or use copper tools constructed monuments of rough blocks of stone."

The discovery that bronze is not obtained from a single ore, but from a mixture of at least two ores, was sure to follow in due course, and when this stage had been reached man had acquired a very substantial degree of metallurgical knowledge and skill. At the zenith of the

* Elliot Smith, *opus cit.*, p. 182.

bronze age some of the workers appear to have become astonishingly proficient in the treatment of metals, and to have regulated the percentages of tin in their alloys to suit particular purposes. Thus, for example, some ten per cent. of tin would be satisfactory for an axe, but a higher percentage, say 11 to 14, would be desirable for a sword. Analysis of ancient implements shows that these proportions were frequently attained.* This fact reflects the greatest credit upon the bronze age metallurgists, for it is obvious that alloys of definite composition could not be ensured by the primitive method of smelting mixtures of ores. Possibly, as Gowland suggests, when implements are found of compositions specially suitable for their intended use, some physical tests had already been applied to the furnace product before using it for manufacturing the tool.

Egypt appears to have been very early in the field in artistic bronze casting, and objects dating back to 3000 B.C. are in existence. They are light and hollow, having been cast with a core of argillaceous sand, which may still be seen in some of the specimens. Bronze was in considerable favour in Nineveh *circa* 1000 B.C., as witness the specimens in Layard's collection at the British Museum, obtained from the ruins of the ancient city. The Assyrians were evidently aware of the influence of tin upon the properties of copper for casting bells, for which purpose alloys containing 14 per cent. of tin were used. In contra-distinction to the Egyptian castings, the earliest Grecian ones were solid and heavy.

In China, again, at a very early date the relative proportions of tin and copper to be used for certain specific castings were laid down for the guidance of the Bronze Age Metallurgist. In the "Records of the Public Works

* Gowland, *Journal of the Institute of Metals*, 1912, vii., 29.

of the Mandarin of Winter," written under the Han Dynasty, *circa* 400 to 230 B.C., is accumulated an enormous mass of detail concerning the arts and industries. "Most valuable facts are recorded with regard to the manufacture of bronze implements and vessels. Bells, tripods, and other sacrificial objects contained one-sixth part of tin in an alloy of copper; hatchets of all sizes contained one-fifth; lances and spears, one-fourth; knives and swords, one-third; erasing knives and arrow-heads, one-fifth; and metallic mirrors, one-half." *

Two bronze swords and a halberd, tentatively assigned to the end of the Bronze Age in China, *i.e.*, *circa* 500 B.C. (see p. 194), are of particular interest in that they have been tinned. The tinning had evidently been performed after the weapons had been polished, presumably to obtain greater superficial hardness. The interior bronze contained

Tin,	16.44 per cent.
Copper,	82.32 "
Lead,	0.15 "
Iron,	0.43 "
Zinc,	0.20 "

with only traces of manganese, nickel, and arsenic. It therefore possessed a composition showing the maximum hardness attainable without brittleness. The surface contained tin only, with traces of copper at the point of contact with the bronze.†

Men who knew how to make weapons such as these were metallurgists of no mean order.

This high metallurgical skill of the bronze age worker prepared the way for the discovery of iron in such districts

* Hirth, "Ancient History of China" (New York, 1908), p. 126.

† Vayson de Pradenne, *Nature*, 1925, cxv., 394.

as possessed ores of that metal near to the surface of the soil. In some districts, no doubt, this metal was already known. Once the greater strength of iron was appreciated, and sufficient skill had been acquired to work it properly, copper and bronze would be relegated to a second position and implements of iron would be employed where hardness and tenacity were essential. Lucretius waxes eloquent in describing this transitional period. "With copper," says he, "they would belabour the soil of the earth, with copper stir up the billows of war and deal about wide gaping wounds and seize cattle and lands; for everything defenceless and unarmed would readily yield to them with arms in hand. Then by slow steps the sword of iron gained ground and the make of the copper sickle became a byword; and with iron they began to plough through the earth's soil and the struggles of wavering war were rendered equal."

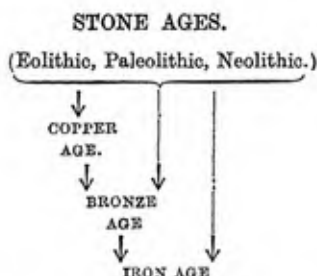
But the development of man has not proceeded along identical lines all over the world. Whilst in many cases a copper or bronze age has succeeded the age of stone, in some countries man has passed direct from stone to iron. Such was the case, for example, in Southern India,* in Australia, New Guinea, and with the inhabitants of the Pacific Islands. In most cases this is probably due to the advent of traders who have brought the iron from more highly civilised countries. There is reason to believe that "the negroes of Africa have had no copper or bronze age, but passed at once into that of iron, because they learned the art of working in iron from Egypt before they knew of any other metal except gold."† In Egypt the iron age was preceded by both a bronze age‡ and a copper age.

* Vincent A. Smith, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 183.

† Ridgeway, "The Early Age of Greece" (Cambridge University Press), 1901, vol. i. p. 599.

‡ Gowland, *loc. cit.* See also p. 159, *et seq.*

Man's upward path may therefore be given diagrammatically as follows :—



These different ages, as they are conveniently termed, do not constitute definite time limits ; rather do they represent stages of civilisation or culture. It is important to bear this in mind, particularly when inquiring as to how long iron, whether telluric, meteoric or manufactured, has been used by man ; for just as the nations to-day differ in the relative degrees of their civilisations, so in past ages like differences occurred. Some of the peoples were living in their stone age, whilst others employed weapons and tools of bronze, and yet others had become familiar with iron. For example, the inhabitants of Britain were using stone implements at a time when Assyria, Egypt, Greece, and also China, were well acquainted with iron. Again, the inhabitants of Thessaly continued to use their stone weapons and their peculiar native pottery long after the culture of the bronze age had penetrated into Crete and Southern Greece. They continued to use them, indeed, until the Cretan bronze age had passed its zenith and the time for the introduction of iron had all but arrived.*

Recent discoveries in Central America by Gann indicate

* Hall, "Aegean Archaeology" (Warner, 1915).

that the Maya civilisation was still in its stone age, *circa* A.D. 400, when practically the whole of Europe had safely passed through its bronze age to the iron age.

Similar variation in culture frequently occurred in one and the same small country. We learn from Roman sources that in 55 B.C., the occasion of the first visit of Julius Cæsar to our shores, the Brigantes in the North were still using weapons of stone, whilst the more cultured inhabitants of the South were familiar with both bronze and iron.*

* See pp. 116, *et seq.*

CHAPTER III.

TRANSITION PERIODS.

THE existence of a hard and fast line of demarcation between the different "ages" mentioned above is not to be expected. This may, in certain cases, be mainly a question of education for the human mind takes time to absorb new ideas. On the other hand, for many obvious reasons a metal cannot be expected to supplant immediately and completely its predecessor. It need occasion no wonder that in certain prehistoric remains, notably those at Hallstadt in the Austrian Tyrol, implements of iron and of bronze have been discovered, lying side by side, indicative of contemporary employment. Could it be expected otherwise? An interesting example in our own country is afforded by a dagger found in the river Witham.* The lower part of its sheath, which is of bronze, is slightly decorated in regular late Celtic style—which fixes its period. The hilt, again, is of bronze, but the blade is of iron, illustrating the overlapping of the two metals.

Two cinerary urns of a common bronze age type have been found at Colchester, one containing, besides the ashes of the dead, an iron-socketed spear head, with lozenge-shaped blade.†

* Clinch, "Handbook of English Antiquities" (Gill, 1905).

† R. A. Smith, "Guide to Early Iron Age Antiquities" (British Museum, 1925), p. 87.

In Egypt, the use of copper can be traced back to shortly before the First Dynasty, *circa* 3500 B.C. Yet stone weapons and implements were in common use down to the Second or Third Dynasty. During many centuries, therefore, copper and stone implements were used side by side, this transition period being termed the "chalcolithic age" (Greek χαλκος, copper). Stone implements were even in use till the close of the Twelfth Dynasty, *circa* 2000 B.C., so that, strictly speaking, the transition age extended to this later date.

Again, iron was known in Egypt even in pre-dynastic times, some 4,000 B.C.,* although it was not in common use until about 1300 B.C., and during the later part of this period it was gradually supplanting copper and bronze.†

It must, of course, be recognised that, from one point of view, later ages are of necessity transitional from the earlier ones, as it can rarely happen that everything in use in earlier epochs is discarded in the later ones. For example‡ "stone has survived for various purposes such as mill-stones, pestles and mortars, and there is evidence to show that axes of stone were employed side by side with those of bronze. For instance, in the Museum of the Royal Irish Academy there are stone axes which undoubtedly exhibit in the shape of their faces the influence of those made of metal. In all ages the poor man, who cannot afford to procure an article of the best and most costly material, must content himself with an inferior, and long after the discovery of copper and the making of

* Petrie (*Journal of the Iron and Steel Institute*, 1912, No. I., p. 182) suggests 6000 to 7000 B.C. But see the chronological table on p. 160.

† The bronze age in Egypt, as distinct from the chalcolithic or copper age, was apparently entered upon only a short time before the iron age.

‡ Ridgeway, *opus cit.*, vol. i., p. 295.

bronze, those who could not afford weapons of that metal had to put up with stone."

"As stone continued in use for certain objects and in a certain sense the stone age has never ceased, so bronze continued to be used for defensive armour, through the Classical Greek and Roman times and through the Middle Ages. Suits of beautiful bronze armour are to be seen in our great armouries, yet the mediaeval knight who donned these bronze breastplates and cuirasses, wielded good swords forged, not of bronze but of stout steel. Bronze offers many advantages over iron for defensive armour. It makes a lighter and more beautiful helmet or cuirass, and does not suffer from rust, the great bane of the harder metal."

At the present day the copper, brass, and bronze industries are of great economic importance, and to this extent, therefore, we are still in transitionary stages, if, indeed, we are minded to press the term to its logical conclusion.

In addition to these true periods of transition between the ages of stone, bronze, and iron, during which the various peoples concerned are gradually being educated to more advanced stages of culture, there are what may be termed *artificial* or *false* periods of transition during which relics of some ancient customs survive long after the age to which they belong has passed away. This may be due to a variety of causes. The temporary force of local circumstances may affect a recrudescence to simpler forms of life, as, for example, when owing to shortage of weapons some of the Saxon troops under Harold at the Battle of Hastings were armed with stone hammers.* An interesting modern example is afforded by Austria, into which country iron coins were introduced soon after

* Clodd, "The Story of Primitive Man" (Newnes, 1897), p. 192.

the great European war had begun. This was owing to the shortage of copper or nickel; Italy followed suit towards the close of the war, whilst Belgium employed zinc.

Religious and personal conservatism each play an important part in national progress. Thus we read that the command went forth to Joshua,* "Make thee knives of flint, and circumcise again the children of Israel." This was done, although bronze knives would have been equally efficient, but the use of metal would have been irreverent. Similarly the stone altars of our churches to-day are interesting historical links with those used by early man when worshipping his gods under the blue arch of heaven—as witness the remains of Stonehenge and elsewhere. The command is still obeyed in our Established Church: † "And there shalt thou build an altar unto the Lord thy God, an altar of stones: thou shalt not lift up any iron tool upon them."

The same veneration came later to be manifested for bronze, iron being regarded with suspicion. Thus, it was an ancient custom to mark out the site of a new town with a bronze ploughshare; ‡ and the priest of Jupiter in ancient Rome was permitted to shave only with a bronze razor. The same idea lies at the root of the fear with which smiths and workers in iron were regarded. Thus Vulcan is endowed with supernatural powers and takes his seat amongst the gods. In the caverns beneath Etna the Cyclopes forged the armour for Achilles; and so on.

Herodotus,§ writing about the year 450 B.C., furnishes

* Joshua v. 2, R.V.

† Deut. xxvii. 5.

‡ See R. A. Smith, "A Guide to the Antiquities of the Bronze Age" (British Museum, 1920), p. 7.

§ See "The History of Herodotus," translated by Rawlinson, Book ii., Chapter 86.

us with an excellent example of the survival of the stone age in his day in connection with the Egyptian habit of embalming their dead. Describing the most expensive process, as carried out for wealthy people, he says: "They take first a crooked piece of *iron*,* and with it draw out the brain through the nostrils, thus getting rid of a portion, while the skull is cleared of the rest by rinsing with drugs; next they make a cut along the flank with a *sharp Ethiopian stone*, and take out the whole contents of the abdomen, which they then cleanse, washing it thoroughly with palm wine, and again frequently with an infusion of pounded aromatics. After this they fill the cavity with the purest bruised myrrh, with cassia, and every other sort of spicery except frankincense, and sew up the opening. Then the body is placed in natrum for seventy days, and covered entirely over. After the expiration of that space of time, which must not be exceeded, the body is washed, and wrapped round, from head to foot, with bandages of fine linen cloth, smeared over with gum, which is used generally by the Egyptians in the place of glue, and in this state it is given back to the relatives, who enclose it in a wooden case which they have had made for the purpose, shaped into the figure of a man."

In so far as his statements can now be checked by archaeological investigation, Herodotus appears to have been a very careful and accurate observer. It is highly probable that he himself witnessed the different processes of embalming being carried out, for a little later in his work (namely, in Chapter 99) he distinctly says: "Thus far I have spoken of Egypt from my own observation, relating what I myself saw, the ideas that I formed, and the results of my own researches."

* Italicised by the present author.

An examination of existing mummies quite confirms the assertion that the brain was extracted through the nostrils, and it is evident that, however skilfully such was done, it would still be desirable to rinse out the skull "with drugs." The most interesting feature of the process, however, from the present point of view, is the statement that whilst a metal tool was employed for clearing the head, a stone knife was used for cutting the abdomen.

Now at the time that Herodotus wrote, namely *circa* 450 B.C., the Egyptians had been familiar with copper for about four thousand years, and even iron had been well known and used for many centuries. After the Twelfth Dynasty, that is *circa* 2000 B.C., implements of stone had ceased to be in ordinary use, so that the embalming knife was a survival of very ancient times.

A curious example of the survival of stone age culture in Egypt within recent years, as the result of personal conservatism, is afforded by Marriete* and by Maspero,† both of whom were acquainted with a Copt in charge of the archæological excavations at Abydos. This man continued to shave his head, throughout his life, with a flint knife. He died when over eighty years of age in 1887 and was still faithful to his flint razor, despite the fact that his sons and the whole population of El Kharbeh were using nothing but steel razors. "As his scalp was scraped nearly raw by the operation, he used to cover his head with fresh leaves to cool the inflamed skin!"

* Marriete, *Bull. Institut égyptien*, 1869-1871, 1st Series, vol. xi. p. 58.

† Maspero, "The Dawn of Civilisation—Egypt and Chaldea." Translated by McClure. (S.P.C.K., 1910.)

CHAPTER IV.

IRON AND THE LANGUAGE.

It is necessary to be very careful when attempting to connect the history of a substance, particularly of one which dates back into remote antiquity, with language. Words frequently undergo striking changes in meaning, which may easily lead the inquirer astray. These changes arise for a variety of reasons. Sometimes they result through confusion or the mistaking of one substance for another. A curious example of this is afforded by cinnabar or vermilion, which was originally known as *minium*, but owing to frequent and excessive adulteration with red lead, the term gradually passed from vermilion to its adulterant. In tracing the early history of either pigment, therefore, this point must be borne in mind. Sometimes it happens that, owing to changed conditions, the discovery of more efficient methods, or a desire to effect a reduction in cost or labour, certain materials are replaced by others, whilst the same name is retained to designate the finished article. Take sealing wax, for example. Only a century ago letters were sealed with wax. But this was never really satisfactory, and in more recent years a resinous material, lac or shellac, has taken its place. But sticks of this are still known as sealing *wax*, although in Germany *Siegelwachs* has given place to *Siegellac*.

A more recent illustration is that of the washerwoman's "copper," which, though now made of iron, retains its

old appellation. Conversely "fire-irons" are frequently made of brass.

In Scotland, oat cakes are still made as in ancient England and Wales, by baking unleavened dough, spread out in thin layers on a *bake-stone*, as it is still called, even though made of iron.*

Again, the names of animals, plants, or things have sometimes passed from the generic to the specific. For example, the word *deer*, originally meant a wild animal or beast, and the same word in German, namely, *Thier*, possesses that significance to-day. Thus the ancient priory-church of Deerhurst, near Tewkesbury, derived its name from the wood or grove of wild beasts in which it was built. But even in Saxon times one animal was, of all others, the highest in repute in the hunting field, and came to be regarded as *the* animal when hunting was the topic. And so in process of time the word deer ceased to mean animals in general, but referred to one animal in particular. In Norman times the word *venison*, which in old French designated the flesh of any animal hunted, came to mean the flesh of *the* animal, the deer. Venison is used in the ancient generic sense, not with its modern specific meaning, in the Old Testament (Genesis xxvii. 3), where we read that Isaac, old and feeble, called for his son Esau, and said, "Take, I pray thee, thy weapons, thy quiver and thy bow, and go out to the field, and take me some venison." Any animal flesh taken in the normal course of the chase would do.

The *leek* has had a similar history, for to the ancient Welsh it was *the* plant of all plants, constituting a favourite food. At the meet, when the farmers helped, in accordance with ancient custom, to plough each other's land,

* Skeat, "The Past at our Doors" (Macmillan, 1911), p. 38.

they brought leeks for their common meal. In the suffix *lic*, the leek survives with its ancient meaning of plant in general, as in *garlic*, which simply means spear-plant.

These examples will suffice to show how careful, how very careful, the student must be, who seeks to unravel the tangled skeins of language, and to lay bare the history of men and things long since forgotten.

The Mexicans called their own copper or bronze "tepuztli," a word that is said to have meant originally "hatchet." The same word is now used for iron, with which metal the Mexicans were already familiar at the time of the Spanish Conquest. Tepuztli then became a general name for metal, and when it was necessary to distinguish copper from iron, the former was termed *red* and the latter *black tepuztli*.* From this it would appear that the Mexican language was spoken before iron was known by the people themselves.

Max Müller adduces reasons for supposing that iron was not known previous to the separation of Aryan nations, since the names for it vary in the different languages.† The Sanskrit word *ayas* referred originally to copper or "the metal." Later on it came to mean iron. Similarly Greek was spoken before iron was known. The Greek word *chalkós* at first referred to copper, but later came to mean iron as the latter metal gradually supplanted the former, whilst *chalkeus*, originally a copper smith, is used in the *Odyssey* ‡ to designate a worker in iron. "To smite with the *chalkós* was equivalent to our phrase 'to smite with the

* Tylor, "Mexico and the Mexicans," 1861, p. 140.

† Max Müller, "Lectures on the Science of Language" (Longmans & Co., 1875), vol. ii., p. 253.

‡ *Odyssey*, ix. 391. See Gladstone, "Homer and the Homeric Age," vol. iii. p. 499.

steel.' As the smith had worked in copper and bronze long before he had ever beaten iron on his anvil, he and his smithy derived their names from the earlier known metal, and the terms *chalkeus* and *chalkeion* continued to designate *blacksmith* and *forge* throughout all classical Greek literature, when beyond all doubt the chief metal wrought by the *chalkeus* was iron."* Later on, however, the Greeks used the word *sidēros* for iron. This would appear to be connected with *sidus*, a star, and is usually regarded as indicating that meteoric iron was known.

The Latin *aes*, and the Gothic *aiz*, both derived from the Sanskrit *ayas*, meant copper or bronze. The Romans were accustomed to use qualifying adjectives in conjunction with *aes* to designate the particular type of metal under consideration. Thus Pliny referred to Cyprian copper as *aes Cyprium*, the word *cuprum* not being coined until many years later. Indeed, Spartianus was the first to use it in the third century. When iron was discovered a fresh word was introduced by the Romans, namely *ferrum*.

These observations may be tabulated as follows :

	Sanskrit.	Latin.	Gothic.	Greek.
COPPER OR BRONZE :	ayas	→ aes	→ aiz	chalkós
	↓		↓	↓
IRON :	ayas	[ferrum].	German eisen.	chalkós and [sidēros].

From this it is fairly evident that Sanskrit, Latin, Gothic, and Greek were spoken before iron was known, that is, the Aryan family had broken up prior to the iron age. And upon the discovery of iron either fresh words were invented (words in square brackets in the above scheme) or old ones adapted for its designation.


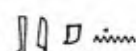
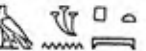

Egyptologists have long insisted on the importance of


* Ridgeway, *opus cit.*, vol. i., p. 295.

the literary evidence in favour of the early knowledge of iron possessed by Egyptians. The word for iron occurs in the early Pyramid texts of Unas; further, some of the weapons in tomb paintings were painted blue and others red, the former being regarded as referring to iron and the latter to copper or bronze.*

Discussing the Egyptian hieroglyphs for iron, Zimmer † says :

"It is significant that nearly all the ancient folk of culture used in their appellation for iron such words which translate into 'Metal, or something hard, from heaven.' Thus the Egyptians used *ba-en-pet*, variously written

or  or  or 
or ; the Assyrians and Babylonians AN.BAR or

parzillu, written thus . It is the same in the language of Sumeria and Chaldea—*barsa*, originally *barsal* and *barzel* respectively, and in the Hebrew *barzel*, פָּרֶזֶל, all having the same meaning, and it does not require a severe stretch of imagination to assume ‡ that by the name 'Metal of Heaven' they meant meteoric iron."

But one must always be careful in giving play to the imagination. The natives of the West Indies, discovered by Columbus in 1492, were totally unfamiliar with iron, though they appear to have known both copper and gold

* See King and Hall, "Egypt and Western Asia in the Light of Recent Discoveries" (S.P.C.K.), 1907, pp. 112-116.

† Zimmer, *Journal of the Iron and Steel Institute*, 1916, No. II., p. 319.

‡ These words are omitted in the original paper by Zimmer, but were evidently intended.

—certainly the latter. They “held the Spanish metals in such estimation that they applied to them an Indian word *Turey*, which seems to have signified anything that descends from heaven.”* There was no question of meteoric origin here, though the natives probably regarded the Spaniards as gods, owing to their relatively white skins—until they disgraced themselves by excesses of every kind.

“It has been suggested that the Egyptian name was comparatively modern and not given to iron till after it had been produced from the ore, simply to signify that such metal sometimes falls, as it were, from heaven. This argument is undoubtedly strengthened by the fact that the earliest larger piece of iron extant and found in the great pyramid is of terrestrial origin. It must also be admitted that the earliest name in the hieroglyphic for iron was *min*. At the time when it was so named meteoric iron was no doubt found and used without the users knowing whence it came, and that its name was changed as soon as its origin was discovered into *ba-en-pet*, and as this change did not take place till the Ptolemaic age was nearly reached, we must admit that it took over 2,000 years to find this out; but there is nothing extraordinary in this, when we consider that out of about 300 iron meteorites known to us to-day only about ten have been seen to fall.”†

A further suggestion is made by Wainwright‡ to the effect that *ba-en-pet* was the name originally given to haematite, which was cut like black marble, into figures or statuettes. When native iron was found in the same

* Helps, “Life of Columbus,” 1859, Chapter viii.

† Zimmer, *loc. cit.*

‡ See “The Labyrinth, Gerzeh and Mazchuneh,” by Petric, Wainwright and Mackay (Quaritch, 1912), p. 19.

localities as the haematite, as it possibly would be at times, it was not at first distinguished, save perhaps by its greater malleability, and so received the same name. In course of time, as iron became better known, the name would pass from the ore to the metal. This theory is, of course, based on the assumption that haematite was actually termed *ba-en-pet*, though at present this is not proven.

CHAPTER V.

IRON AS ORNAMENT.

VARIOUS causes contribute to the esteem in which a substance is held by any particular people. They may be purely æsthetic, utilitarian, or a mixture of the two. Thus gold is valued mainly for its beauty and incorrodibility, whilst iron is so useful that it may almost be said to constitute the hub of modern civilisation. Small wonder is it then that, owing to its comparative scarcity, iron should have been regarded in early times as a valuable possession. Possibly the earliest known use of iron for ornamental purposes is its inclusion as beads in a necklace found in a pre-dynastic tomb in Egypt, along with gold and carnelian. This probably dates back some 4000 B.C.* Mention is made in the sequel of the fact that in the Homeric Age (*circa* 1400 to 1200 B.C.) iron was repeatedly referred to along with the treasures of the wealthy.

According to Ridgeway the earliest reference to iron as occurring in Assyria dates back to 1400 B.C., being contained in the Tel el Amarna tablets, which speak of iron rings covered with gold.

It is interesting to note in this connection that iron was used, though probably not extensively, for personal adornment about the time of its introduction into Palestine (*circa* 1000 B.C.). Thus at Gezer various iron objects have been unearthed, including pendants, bracelets,

* See p. 159.

anklets, and rings. In one case the remains of a ring lie "fastened by corrosion to the finger bone, which proves with sufficient clearness that the ring in question is not part of an implement, but a finger ring. The same fact is attested by the various iron signet-rings which have been found."*

The use of anklets is a very ancient custom and is referred to in Holy Writ,† where the Lord saith, "Because the daughters of Zion are haughty, and walk with stretched forth necks and wanton eyes, walking and mincing as they go, and making a tinkling with their feet. . . ."

Curious how attractive to the Easterns, as also to primitive races, are the sounds of tinkling metals, sounds that would, on such constant re-iteration, worry a European to distraction. In Africa, too, iron has been used very largely by the natives in the interior right down to modern times for purposes of personal adornment. Schweinfurth ‡ frequently refers to this in the account of his travels in Central Africa during the years 1868 to 1871. The Bongo and Dyoor tribes loaded themselves heavily with iron rings, etc., their arms looking almost as if they were protected with heavy armour such as that worn by European knights in the 13th and 14th centuries. Armlets or bracelets are not necessarily intended to be only ornamental. As a rule they are more solid than necklaces and can be more easily removed. As Davenport points out § a sharp circlet of shell or metal kept on the wrist can conceivably have been of great effect as a missile.

* Hancock, "Archæology of the Holy Land" (Unwin, 1916), p. 210. Also see Macalister, "Excavation of Gezer" (3 volumes), published under the auspices of the Palestine Exploration Fund.

† Isaiah iii., 16, 18. Also "The Koran," Sura, xxiv., 31.

‡ Schweinfurth, "The Heart of Africa" (Sampson Low), p. 81, *et seq.*

§ Davenport, "Jewellery." Little Books on Art (Methuen, 1913), p. 92.

A somewhat similar weapon is worn by native warriors in some parts of India. It is a flat circlet of steel kept in the helmet, and it is stated by a competent authority that such skill in the throwing of these rings can be obtained that the trained natives can cut off a man's head with one of them at a considerable distance.

"A similar use of iron bracelets is credited to some of the savages of the Congo districts; and others wear shell discs with sharp edges, protected in time of peace in leather coverings."

"Others, living about the Upper Nile, have heavy spiked bracelets, which can be used as deadly weapons."

Livingstone* mentions an interesting case of anklet-wearing that came under his own personal observation in his travels through the central portion of Southern Africa about the year 1850. The favourite wife of the chief Sheakondo was adorned with a profusion of iron rings on her ankles, to which were attached little pieces of sheet iron to enable her "to make a tinkling as she walked in her mincing African style." Others were ornamented with rings of copper, or a mixed assemblage of copper and iron. Some chiefs were so heavily loaded with these encumbrances that they were forced to strut about with their feet wide apart. This ungainly walk apparently found favour with the younger bloods, who imitated it even when wearing only light rings, and the natives remarked to Livingstone that that was the way in which they showed off their "lordship" in those parts.

Anklets are worn also in Egypt, India, Sumatra, and probably elsewhere among primitive peoples, though not necessarily of iron, silver and other metals being also used, and often they are beautifully decorated.

* Livingstone, "Missionary Travels" (Ward, Lock), pp. 237, 240, 254.

Speaking of the excavations amongst the ruins of ancient Chaldea, Rawlinson* states that "Iron . . . is extremely uncommon, and, when it occurs, is chiefly used for the rings and bangles which seem to have been the favourite adornment of the people."

Pliny,† in a lengthy discourse on rings, states that at the time of the Second Punic War (218 to 201 B.C.) rings were in very general use. These were mostly of gold, but Pliny is careful to add that "not even in those days did all the senators possess gold rings, seeing that, in the memory of our grandsires, many personages who had even filled the prætorship wore rings of iron to the end of their lives." In Pliny's own day iron was a much more common commodity, and when slaves wore rings of iron they were allowed to encase them with gold. Apparently, however, slaves were not allowed to wear pure gold rings, the use of which was confined to the free.

It is not impossible that the modern use of iron or steel finger rings to "cure" rheumatism is a relic of those times when iron was supposed to ward off attacks of the evil one. The idea that as the iron rusts it draws out the rheumatism is reminiscent of the old cure for toothache, according to which an iron nail is hammered into a tree and as it rusts so will the toothache disappear!

The wedding rings of the Romans were generally of iron and called *Pronubum*, symbolic of the lasting character of the engagement. Very probably this originated in another Roman custom, namely, the bestowal of a ring as an earnest upon the conclusion of a bargain.‡ It is stated also that in Rome it was at one time customary

* Rawlinson, "Five Great Monarchies," vol. i., pp. 98-99.

† Pliny, "Natural History." Translated by Bostock and Riley (Bohn, 1857), Book xxxiii., chapter 6.

‡ William Jones, "Finger Ring Lore" (London, 1877), p. 303.

to give a newly made bride a ring of pure gold and to send at the same time an iron ring to her parents as a remembrance of modesty and domestic frugality.

A small iron ring, dating probably from the sixth century, was found in a Coptic grave near the Temple of Medinet Aboo, at Thebes. On it was engraved the lion of St. Mark.*

The invention of the ring has been ascribed to Tubal Cain. In an old Latin work it is stated that "the form of the ring being circular, that is, round, and without end, importeth this much, that mutual love and hearty affection should roundly flow from one to the other, as in a circle, and that continually and for ever." The same idea is conveyed by Woodward, 1730, who, on presenting Phoebe with a ring says †

"Accept, fair maid, *this earnest of my love,*
Be this the type, let this my passion prove ;
 Thus may our joy in endless circles run,
 Fresh as the light, and restless as the Sun ;
 Thus may our lives *be one perpetual round,*
 Nor care nor sorrow ever shall be found."

It is well known that in the so-called Dark Ages, hollow rings filled with dangerous poisons were commonly used. Hannibal had one such, for example, and swallowed the poison when in fear of being delivered up to the Romans. Demosthenes is believed to have destroyed himself in a similar manner.

An interesting story of a poison ring appeared in the French newspapers many years ago,‡ according to which "a gentleman who had purchased some objects of art at a shop in the Rue St. Honoré, was examining an ancient ring, when he gave himself a slight scratch on the hand with a sharp part of it. He continued talking to the dealer

* Jones, *ibid.*, p. 273.

† Jones, *ibid.*, p. 276.

‡ Jones, *ibid.*, p. 435.

for a short time, when he suddenly felt an indescribable sensation over his whole body, which appeared to paralyse his faculties, and he became so seriously ill that it was found necessary to send for a medical man. The doctor immediately discovered every symptom of poisoning by some mineral substance. He applied strong antidotes, and in a short time the gentleman was in a measure recovered. The ring in question having been examined by the medical man, who had long resided in Venice, was found to be what was formerly called a "death" ring, in use by Italians when acts of poisoning were frequent about the middle of the seventeenth century. Attached to it inside were two claws of a lion, made of the sharpest steel, and having clefts in them filled with a violent poison. In a crowded assembly, or in a ball, the wearer of this fatal ring, wishing to exercise revenge on any person, would take their hand and, when pressing in the sharp claw, would be sure to inflict a slight scratch on the skin. This was enough, for on the following morning the victim would be sure to be found dead."

It is interesting to note that when, during the great war of liberation in Germany, the ladies deposited their jewels in the public treasury to be sold for the national cause, they each received in return an iron ring bearing the inscription, "Ich gab Gold am Eisen."

Iron rings are not unknown in the relics of ancient Britain, several of late Keltic Age having been found, for example, at the Lake Village of Glastonbury.

Iron brooches have been unearthed at La Tène in Switzerland (see p. 88), dating back to the third century before our era. At Wookey Hole, in Somerset, iron brooches have been found of Romano-British age. They are penannular in shape, the terminals being slightly knobbed to prevent the pin from slipping out. They

were used by "first inserting the pin to bring two folds of the garment together, and then turning round the imperfect ring till its end caught beneath the pin and so retained it in place."*

Mention may here be made of the fact that steel jewellery, as apart from mere savage ornament, appears to have been invented in England, and a very fine collection may be seen in the Museum at Birmingham, which city was the centre of its manufacture, from whence it found its way all over Europe. Missen, noticing in 1690 the "swords, heads of canes, snuff-boxes," and other fine works at Milan, remarked that they could be had of better quality and more cheaply in Birmingham! Both Wolverhampton and Birmingham became famous for the character of their artistic productions in steel, which comprised chains, chatelaines, buttons, buckles, clasps, pursemounts and seals. They were frequently embellished with fine cameo-like productions of wedgwood, in blue and white "jasper," or painted enamels executed at Bilston and Battersea. Parisian traders frequently sent over beautiful enamels to be set in steel mounts. Sword-hilts, too, were produced in cut steel in considerable numbers. This steel jewellery was in high favour in the middle of the eighteenth century, and was manufactured by Boulton and Watts at Soho, men who are famous for their work in another walk of life. Towards the middle of the nineteenth century, however, steel jewellery began to go out of fashion. The use of steel cut as "gems" was abandoned in favour of a cheaper substitute of steel beads strung into loops and tassels; these were again in turn discarded, and steel jewellery became obsolete. No doubt the tendency of the metal to tarnish in a moist atmosphere

* Herbert E. Balch, "Wookey Hole, its Caves and Cave Dwellers" (Oxford University Press, 1914), p. 92.

such as ours militated against its continued use, for when polished the metal yields most attractive articles, of surprising brilliance, as a study of the specimens in the Museum referred to will show. It is of interest to observe whether or not steel jewellery will once more come into favour, now that "stainless," high chromium steel has been prepared.

CHAPTER VI.

IRON AS CURRENCY.

WHEN Julius Cæsar visited these islands he found the southern tribes in Britain were using iron bars as currency, just as in certain parts of Africa, up till the outbreak of the Great European War in 1914, native races used bars of iron as media for exchange and mart. Referring to the Britons, Cæsar says,* "The number of the people is countless, and their buildings exceedingly numerous, for the most part very like those of the Gauls; the number of cattle is great. They use either brass or iron rings, determined at a certain weight, as their money. Tin is produced in the midland regions; in the maritime, iron; but the quantity of it is small."

Of course coinage was not unknown at this time to the Britons. There already existed an old established trade between Britain and the Continent, and coins had been introduced from Gaul some 200 B.C. With these the Southern tribes must have been thoroughly familiar.

Many of these early British currency bars have been discovered in various parts of the south of England. Some of them are heavily corroded, whilst others are in a surprisingly good state of preservation.

The localities in which the finds have been made are as follows :—

* Cæsar, *De bello Gallico*. Book V., chapter xii. Translated by MacDevitt.

Localities and Numbers of Currency=Bars Found.*Berkshire—*

Maidenhead (seven or eight in bundle).

Devon—

Holne Chase (about twelve specimens).

Dorset—

Hod Hill (at least seventeen found).

Spettisbury (at least five found).

Gloucestershire—

Meon Hill (hoard of 394).

Bourton-on-the-Water (two hoards; numbers given as 147, 140, and 120).

Hampshire—

Winchester, Worthy Down (13 bars, 7 perfect).

Isle of Wight—

Ventnor (two found together 6 feet deep).

Northants—

Hunsbury (one specimen).

Somerset—

Wookey Hole (three specimens in fragments).

Glastonbury (two of different denominations).

Ham Hill or Hamdon (large number found).

Wiltshire—

Minety (one specimen).

Worcestershire—

Malvern (two hoards of 150 each).

Littleton (one specimen, perfect, found in 1822; now in Worcester Museum).

The Glastonbury specimens are particularly interesting, having been found "on the site of the marsh village, where there is no trace of contact with Roman civilisation, and the barest evidence of a native British coinage." *

* Reginald A. Smith, "A Guide to the Antiquities of the Early Iron Age" (British Museum, 1905), p. 149; also *Proceedings of the Society of Antiquaries*, 1905, vol. xx. p. 179.

In connection with the Hunsbury Hill (Northants) specimen it is interesting to note the entire absence of British coins. This, however, "is not surprising in view of the early La Tène brooches found there, dating from about 400 B.C.; and the obvious inference is that the iron currency is earlier than the coins in districts where both are found. No currency-bars from the eastern counties, Kent, Surrey, or Sussex have been found, or at least published; but as those parts of England nearest the Continent were in Cæsar's time ahead of the interior in all branches of civilisation, it is possible that the iron currency was from the first confined to the centre of Southern England, where it was subsequently superseded by the gold coinage introduced from the south-east. But though the British mints no doubt began in the second century before the Christian era, Cæsar's mention of the bar-currency (which he probably saw in use) shows that the coinage was not fully established in the interior at the time of his descent on Britain." *

"The introduction of the use of money into Gloucestershire and the north of Wilts. and Somerset does not appear to have taken place until some time after the days of Julius Cæsar." †

The bars bear a close resemblance to partly finished swords and consist of a flat, slightly tapering blade with blunt rectangular edges. A rude handle was formed by turning up the edges so as to meet one another at a point some 2 inches from one end, as shown in Fig. 1.

Some of these bars may be seen at the British Museum, others at the Victoria Institute Museum, Worcester. It is by no means improbable that yet other currency bars

* Reginald A. Smith, *Proceedings of the Society of Antiquaries*, 1915, vol. xxvii. p. 69.

† Evans, "Coins of the Ancient Britons," p. 41.

are lying unrecognised in different collections and possibly catalogued as unfinished swords or under other names.

The suggestion that these bars were never intended to be swords, but are the actual remains of the currency bars mentioned by Cæsar, was first put forward by Reginald A. Smith,* of the British Museum, who offers the following arguments in favour of his theory :

1. Considerable numbers of these bars have been found at times hidden away in the same place. Thus, for example, in 1824 some 394 bars were unearthed from the centre of the British camp at Meon Hill in Gloucestershire, whilst several other hoards have been located at places mentioned in the table on p. 51. It is in the highest degree improbable that the Britons would trouble to bury half-made swords at a crisis ; but they might

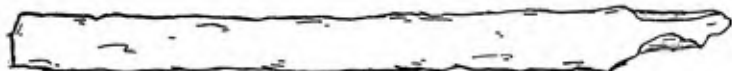


Fig. 1.—British Currency Bar. Length, 12·72 inches.
Weight, 1,933 grains. Worcester Museum.

well be expected to bury their treasure in the hope of recovering it at a later date.

2. The bars are not uniform in size or weight, some bars being as much as sixteen times heavier than others. Only a small percentage of them, therefore, could contain the right amount of metal to yield a sword of the period.

3. The most convincing argument, however, is to be found in the remarkable observation that the weights of

* Major-General A. Lane Fox (afterwards Pitt-Rivers) had a suspicion as early as 1877, when excavating at Mount Caburn Camp, that certain iron bars were employed as a medium of exchange in Britain. "It would appear not at all improbable," he wrote, "that half-wrought implements of this kind may have been used as a kind of currency" (*Archæologia*, xlvii., 435).

the heavier bars must originally have been simple multiples of the weights of the smaller bars.

All the bars as yet described have suffered some loss in weight in consequence of corrosion. Fortunately, however, although some bars have corroded to destruction, others have been found in a relatively good condition, and it is possible to arrive at a rough estimate of their original weight. When this is done, it is found that the weights approximated to 309 grammes (4,770 grains), or to some multiple or sub-multiple of this amount. In all, no fewer than six different sizes have been found, of the following presumed standard weights :

Presumed Standard Weights of Currency Bars.

	Grammes.	Grains.	Ounces Avoirdupois.
Quarter,	77	1,193	2 $\frac{3}{4}$
Half,	154.5	2,385	5 $\frac{1}{2}$
Unit,	309	4,770	11
One and a half,	463.5	7,155	16 $\frac{1}{2}$
Double,	618	9,540	22
Quadruple,	1,236	19,080	44

The third size has been chosen as the unit, namely 4,770 grains, owing to the fact that there lies in the Cardiff Museum a bronze weight which was found in association with enamelled bronze ornaments of Late Celtic character near Neath in Glamorganshire. On the top of this weight is engraved the figure I., and it weighs 4,770 grains. A similar weight, but in basalt, lies or rather did lie before the outbreak of the great European war in 1914, in the Mainz Museum. It bears the mark I, and weighs 4,767 grains, that is, the same as the preceding within the primitive range of measurement. These

weights represent half an Attic commercial mina of the period prior to 160 B.C., and show that even at this early date Britain recognised the same standard weights as the Continent.

Yet a third weight has been described, hailing from the province of Namur. It " bore the mark |||| and weighed ' 1 kilogramme 25 centigrammes ($2\frac{1}{2}$ livres).' An appeal to a well-known almanack puts us in a dilemma. A centigramme being the hundredth part of a gramme, the weight would be $1,000 \cdot 25$ grammes = 15,404 grains ; but according to the same authority the French pound is 7,554 grains, and the alternative weight of the bar is therefore 18,885 grains, that is about 3,480 grains or 8 oz. Av. more than 1 kilogramme 25 centigrammes. Scientific accuracy cannot be expected in the division or weighing of rude iron bars, but this margin is anything but a trifle ; and the uncertainty is all the more annoying as the weight was evidently four times the unit of a system, and was found with a large amphora, silver denarii, including one apparently of Faustina the elder, pottery, and a brass of Septimius Severus (193-211). The weight was 2.6 inches in diameter, and had been cracked by fire, which probably diminished the weight to some extent. If we suppose centigramme (0.154 grain) a mistake for dekagramme (154 grains), the weight would be $15,400 + 3,850 = 19,250$ grains, somewhat in excess of $2\frac{1}{2}$ French pounds, but perhaps that was meant only as a rough approximation. The unit in that case would be 4,812 grains, against the British unit of 4,770 grains."*

The Wookey Hole specimens † have an interest of their own. Two of them are fragments of bars of unit and half

* R. A. Smith, *loc. cit.*

† Herbert E. Balch, "Wookey Hole, its Caves and Cave Dwellers" (Oxford University Press, 1914), p. 88.

unit weight respectively. The third is a quarter unit bar, 10·9 inches long and half an inch wide, weighing 1,040 grains. It is in two practically equal portions which were found lying together, and weigh 510 and 530 grains respectively. As the line of division is so square cut, it has been supposed that the bar has been marked with an incision with a view to subdivision, and that nature has effected this partition by corrosion.

It is curious to note that the iron handle of a bucket, likewise found at Wookey Hole, is of exactly the form and size as the above mentioned currency bar. This appears to indicate that, upon occasion, iron currency bars might be used for other purposes than exchange or mart.

Two British currency bars were examined by the late Professor Gowland, who reported that one (bar B) was similar in structure to iron produced by primitive methods such, for example, as those adapted in the heart of Africa by the natives at the present time. The other (bar A) resembled meteoric iron, both in analysis (it contained nickel) and in microstructure. This is an observation of particular interest in view of what has been said on pp. 9 to 14.

The analyses were as follows :*

	Bar A.	Bar B.
Carbon,	trace	0·08
Silicon,	0·09	0·02
Phosphorus, . .	0·69	0·35
Manganese, . . .	nil	nil
Nickel,	0·23	nil

More recently the bars found on the site of a prehistoric

* Quoted by Brough, *Journal of the Iron and Steel Institute*, 1906, No. I. p. 233.

village on Worthy Down, near Winchester, have been analysed and studied micrographically with interesting results.* The chemical analysis was as follows :

	Per cent.
Carbon (combined),	0.06
Silicon,	0.11
Sulphur,	0.014
Phosphorus,	0.954
Manganese,	trace†
Nickel,	trace

The high phosphorus and low manganese content are noteworthy, the ancient direct-process metal thus differing markedly from modern wrought irons, which are made by indirect methods, and which usually contain : ‡

	Per cent.
Phosphorus,	0.215
Manganese,	0.10

The micrographic structure and the almost entire absence of nickel pointed to the artificial production of the metal. The grains were comparatively coarse and the slag bands relatively broad. Prolonged etching with alcoholic picric acid revealed the presence of elongated aggregates of small foliations which Myers attributes to the "irregular distribution of phosphorus in the solid solution of phosphorus in iron, and the cause, in part, may be due to the movements of both carbon and phosphorus in their respective solid solutions."

In 1918 Stead§ showed by means of cupric reagents that, where extraneous carbon is introduced into phos-

* Myers, *Journal of the Society of Chemical Industry*, 1922, vol. xli., p. 133T.

† In one specimen no manganese could be detected.

‡ Means of twelve commercial specimens used in the present author's Researches on Corrosion.

§ Stead, *Journal of the Iron and Steel Institute*, 1918, No. I., p. 389.

phoric iron, phosphorus tends to diffuse away from those areas where the carbon penetrates. Two years later Whiteley* found that in the presence of carbon part of the phosphorus contained in γ -iron, between Ac_1 and Ac_3 , diffuses into the adjacent ferrite in which it is more soluble. Now the minute pearlitic areas in the currency bar under examination † "clearly show this phosphorus diffusion, and prove that the metal was reheated for some time between 800° and 900° C., followed by fairly rapid air cooling."

It is a wonderful tribute to modern science that it should be possible to determine from purely internal evidence how a primitive worker in pre-Roman times in these islands prepared and heat-treated his metals.

It is now generally recognised that the Druids were the most cultured and highly educated class amongst the ancient Britons, and that they had attained to a relatively high standard of scientific knowledge. Indeed, so great was their renown that young men flocked over to Britain from the Continent in order to receive instruction at first hand from them. England was the Charlottenburg of Western Europe.

Amongst other things the Druids practised astronomy. Now in Eastern countries where the sky is clear the study of astronomy is much more easy, and appeals much more strongly to the popular mind, than in our clouded islands. But little advance could be made without some method of telling the time. In the east, sundials were used by day and clock-stars by night, but these would be relatively useless beneath our leaden skies. The Druids, therefore, were compelled to adopt some mechanical device to measure the passage of time, and in all probability the

* Whiteley, *ibid.*, 1920, No. I., p. 359.

† Myers, *loc. cit.*

water clock used by them was a *British invention*, as we shall see presently.

Until a few years ago practically nothing was known about British Water Clocks, and we are again indebted to Reginald A. Smith for bringing the subject to the fore.*

At the time at which he wrote his first paper on the subject, namely in 1907, there were in the British Museum a number of early British cauldrons or bowls made of bronze, and more or less ornamented. The curious feature about many of these is the fact that they are perforated at the base, just like a flower pot. What purpose could this perforation serve?

One of the most interesting of these bowls was discovered at Baschurch in Shropshire, and had been presented to the Museum several years previously. It is described by Smith as follows:—

“Though considerably damaged in the upper part, the vessel can be easily restored in imagination, and is of circular form, the bronze being beaten out with astonishing skill so that the least thickness consistent with stability is obtained. The base is symmetrically rounded, the lower part of the body has a somewhat rounded shoulder, and the upper part or neck is practically vertical. Its present weight is 3 lbs. 7½ ozs. avoirdupois, and above 6 ozs. of metal is missing; the maximum diameter is 17¾ inches, height 12 inches, and diameter of mouth 17.6 inches. At two opposite points are small round holes in the sides about 1¼ inches from the top edge, and 4 inches below each is a similar hole. These were evidently intended for riveting an anchor-shaped mount or iron to each side, as the outline is still indicated by rust, and is very plain in one case. Besides these two pairs of rivet-holes is another

* R. A. Smith, *Proceedings of the Society of Antiquaries*, 1907, xxi., 319; 1915, xxvii., 76.

single round hole 1 inch from the top, its position measured along the circumference being $18\frac{1}{2}$ inches from one pair and $8\frac{1}{4}$ from the other. It has evidently been placed symmetrically, and is just one-third of the diameter from one pair of holes, the entire circuit of vessel at this level being between 55 and 56 inches. In the missing portion of the neck was evidently a third hole, doubtless for attaching a cord or some other means of lifting it, but whether the two sets of holes were made at the same time it is difficult to say. The main point about this vessel is, however, the perforated base; in the centre is a neatly made hole, round like those for the rivets, but somewhat larger, with a diameter of exactly one-fifth inch = 0.5 cm. As this cannot have been used for fastening it to a stand of any kind, another explanation had to be found, and an analogy might at once suggest itself to anyone familiar with the water clocks of India and Ceylon. In the British Museum is a copper bowl made for the measurement of time; it was obtained by the late Mr. Hugh Nevill in Ceylon, where such are to this day in use for purposes of astrology, but no longer serve to mark the flight of time. This beautifully made little vessel weighs 680 grains ($11\frac{1}{2}$ ounces), has a diameter of $4\frac{1}{2}$ inches, and a height of $1\frac{1}{2}$ inches. There is a slight indentation in the rounded base, and in the centre a very small perforation the size of a pin-hole. If placed in a bowl of cold water, it will gradually fill through the hole in the base, and will sink in about $19\frac{1}{2}$ minutes."

The bronze vessel just described is undoubtedly an early British water clock intended to work in the same manner as the Ceylonese specimen. This is particularly interesting, because the classical water clocks of the Greeks, Romans and Egyptians were worked on a different plan.

The Egyptians, who are usually credited with the invention of the clepsydra or water clock, employed two forms, but both based on the principle that water falling from a constant level into a vessel raises a float which marks the time.

In the Roman law courts another form was used, in which water was allowed to trickle through on the same principle as our ancient hour glasses or more modern egg timers, sand being used by us instead of water.

The custom of using water clocks as a check upon the speakers in the Courts of Justice at Rome was introduced by Cn. Pompeius in his third consulship. Before that time speakers had been allowed to plead as long as they chose, but that privilege being, like most others at various times, abused, it was decided to allow certain lengths of time according to the importance of the case. Pliny states that upon one important occasion he spoke for nearly five hours, ten large clepsydræ having been granted to him, but the case was so important that four others were added. The Roman legionaries had water clocks for measuring the 3-hour watches of their sentries, and Cæsar mentions that during his campaigns in Britain the time was measured by accurate water measures.

At Wotton in Surrey another interesting discovery was made. This was in September, 1914, on the estate of the Evelyn family, and consisted of a hoard of bronze vessels, amongst which were several perforated bowls or water clocks, similar to the one already described, and a curious vessel very much like a frying pan. All are now safely deposited in the British Museum.

The bronzes had been packed together with hay, and the hard sand all round was found on careful examination to be undisturbed, so that the objects may be presumed to constitute the entire deposit. Ten vessels can be

distinguished the smaller being in good or fair condition, and now restored to shape with a little solder and wire; but the four larger and thinner specimens have suffered severely.

The vessel shaped like a frying pan is of special interest. It is described as a vessel of "stout metal with base between an oblong and oval, and sides bent outwards, but not far from vertical." At the ends the sides gradually rise 1·6 inches vertically above the bottom, the normal height being 1·2 inches. The base measures outside 9·5 by 8·2 inches, and is practically flat. All that is left of the handle is a plate 1·7 inches long, with a vertical iron rivet and a pair of bronze ears bent over to form a socket, and pierced by a stout iron pin still in position, and partly embedded in a ferruginous mass of sand cemented by iron rust. Other similar frying-pan-like vessels have been discovered elsewhere, and R. A. Smith considers that they were used as gongs, being struck every time the bowl sank in the water, by an attendant or time keeper, whose sole duty consisted in thus measuring the time. He was thus not altogether unlike our night watchmen of a century ago, but his duties continued in the day time as well.

It is interesting to note that a similar method of recording the time has been adopted in India for many centuries, and an account of the method is given by Thurston, Superintendent of the Madras Government Museum, who quotes from a work on religious ceremony dated 1731, as follows:—

"The inhabitants of Mogul measure time by a water-clock, which, however, is very different from our clepsydra or hour glass. It is in their language called gari or gadli, and has not so much work in it, but requires more attention, a man being obliged to watch it continually.

It is a basin filled with water on which they put a little copper dish with a very small hole at its base. The water comes by insensible degrees into this dish, which sinks to the bottom when full, the water in it mixing with that in the basin. The time taken in filling is by them called a *gari*, which (according to the author's observation) amounts to 22 minutes 30 seconds of time ; so that when the day is exactly 12 hours in length, each part (or watch) contains eight *garies*, that is, 180 minutes or 3 hours. As the days shorten there are fewer *garies* in each part of the day and more in those of the night, the whole 24 hours always containing 64 *garies*. As soon as one *gari* is ended, the attendant strikes as many blows on a copper table as there are *garies* passed, after which he strikes others to show the part of the day or night."

In Nepal the measurement of time is regulated in the same manner, a gong being struck in progressive numbers from dawn to noon every time the vessel sinks ; after noon the gong indicates the number of *garies* remaining before sunset. In Burma also a copper time-measurer or *nayi* was used, and a gong sounded every third hour in the time-keeper's tower within the palace precincts. To ensure attention to his duties the time-keeper could by law be sold in the public market if negligent.

Dr. Fleet, who is an authority on things Indian, states that the percolating form of water clock was not known to the Hindoos till after A.D. 350, so that the ancient Britons could not have derived their system from India. The classical water clock was of a different pattern, as we have already seen, so that unless the British pattern can be traced to Babylon the conclusion seems inevitable that it must have been a British invention.

And now for an observation of surpassing interest. It is not possible to estimate the original weight of all the

bronze water clocks because parts are frequently missing. But five of them from the Wotton hoard have clearly lost but little in weight, and when an estimate is made of this loss, it appears that the original weights were either identical with or multiples of that of the unit currency bar.

Thus—

Bowl 1 had unit weight.				
„	8	„	$1\frac{1}{2}$	units weight.
„	9	„	2	„ „
„	7	„	$2\frac{1}{2}$	„ „
„	6	„	3	„ „

This is very curious, for although different denominations of currency would readily be expected as civilisation advanced, it seems remarkable that early artificers should have taken the trouble to regulate the weight of their clocks, when by simply adjusting the size of the hole the rate of sinking in water could be regulated to that required. However, this is precisely what the Hindoos used to do, very definite instructions having been laid down by them as to the weights of the sinking bowls.

It is difficult to say when bar currency became obsolete in these islands, because different districts varied enormously in their relative states of civilisation. For example, even three centuries after Cæsar's first visit there were, an early writer informs us, Britons living in outlying marshy districts, possibly the Cambridgeshire Fens, who "encircled their loins and necks with iron, deeming it an ornament and evidence of opulence, in like manner as other barbarians esteem gold."

The use of bars as a medium of barter dates back to very early times. They were employed by the early

Greeks, and Déchelette* derived them from the spits used for roasting flesh, a handful being called a *drachm*, in the original sense of that word. It is said that Pheidon of Argos deposited in the Heraeum certain iron bars that had till his time, namely, prior to 600 B.C., done duty as money. Whether these bars had been called in as being obsolete, "or in order to preserve the standard weight or dimensions, has been disputed; but the fact remains that such a deposit has been discovered there in recent times; and Déchelette drew attention to a bundle of spits carried by an attendant in the procession represented on the Certosa bucket. They occur also in Etruscan tombs of the eighth to sixth centuries; and retained their original form in Gaul at least to the end of the fifth century B.C., as specimens were found in the warrior's tomb of Somme Bionne."†

It is difficult to understand how the idea of using currency bars reached this country, since none of the peoples between Britain and Greece appear to have adopted the system. Possibly this is but another example of two peoples each independently hitting upon the same idea.

Of course, bars, coins, paper money, and what not, are simply objects of convenience for trade, and in themselves may have but little intrinsic value. It is surprising how easily we can fall back into primitive methods of bargaining if necessity arises. This was the case in many rural parts of Germany at the close of the war, and, for all the present writer knows to the contrary, may have obtained elsewhere also.

Writing not long ago (1921) from a rural district in Prussia, a gentleman stated that one of his maids "went

* Déchelette, *Manual d'archéologie préhistorique*, vol. ii., Part 2, p. 799; Part 3, p. 1557.

† R. A. Smith, *loc. cit.*

to the next town, taking with her 4 lbs. of butter, which then cost 15,000,000,000 marks a pound. She asked in a shop the price of a skirt, and offered the sum in butter. The skirt was at once wrapped up for her. The people in the shops will always barter against food, because it is so hard to obtain."

When the Cape of Good Hope was first colonised, the Hottentots were found to be using cattle and bars of iron in place of coins. Similarly on the west coast of Africa the *bar* is, or was prior to the Great European War, the unit of currency, all merchandise being reckoned by it. It had a definite monetary value, although originally it referred to the exchange value of a bar of iron of fixed dimensions, with which the early European traders were accustomed to barter with the natives.

Schweinfurth states that equivalents for money were possessed by the natives in Central Africa (1868-1871) in the form of the so-called *loggoh kullutty* and *loggoh melot*, made by the Bongo tribe. A rough sketch is given in Fig. 2.

The *loggoh kullutty* is an iron, spade-like article, formed in flat discs from 10 to 12 inches in diameter. On one edge is a short handle, whilst on the diametrically opposite edge is a projecting limb something like an anchor. The *loggoh melot* is similar, but without the small projecting limbs. It is in this form that iron is stored amongst the treasures of the wealthy, and serves in place of money for commercial exchange and for marriage portions.

In Cambodia, Indo-China, iron ingots are used as a special kind of money or currency. They are not weighed, but are as long as from the base of the thumb to the tip of the forefinger; they are two fingers in breadth, and one finger thick in the middle, tapering off to either end.

Measurements of this kind appear crude to the scientific mind of to-day. But it is well to remember that the *carat*, the standard employed in weighing diamonds, is merely the average weight of the seed of the locust tree, although in more recent years its value has been fixed at 3.1683 grains or 205.310 milligrammes by the Board of Trade in order to reduce the danger of disputes. The French carat is 200 milligrammes. Similarly three barley corns were at one time taken to measure an inch, and the heights of horses are still measured in "hands," a term reminiscent of the time when the span of the average human hand was

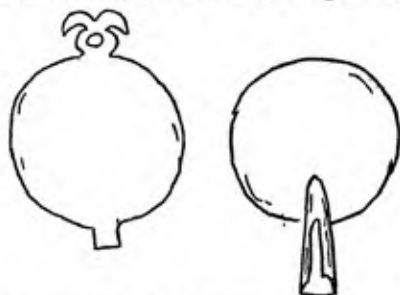


Fig. 2.—Spade-like Currency of the Bongo. Left, the Loggoh Kullotty; right, the Loggoh Melot.

regarded as a sufficiently accurate standard of measurement.

It is by no means improbable that Christ had treasure of the above kind in mind when He enjoined His followers not to lay up stores on earth "where moth and rust doth consume."* The same idea of corrosion occurs in connection with gold and silver in the Book of James, where we read that "your gold and your silver are rusted; and their rust shall be for a testimony against you."† But the Greek words translated *rust* in the above passages are not the same in both cases.

* Matt. vi. 19, R.V.

† James v. 3, R.V.

CHAPTER VII.

IRON IN EUROPE.

It would appear that the Greeks and the Cretans were amongst the first European people to use iron. According to Montelius* the Grecian iron age commenced about 1400 B.C., but for most of the Keltic and Teutonic peoples the iron age did not commence until about 500 B.C.†

Iron and Homer.—Homer, who lived about 880 B.C.,‡ was very familiar with the metal. The Homeric Age, however, as depicted by the *Iliad* and *Odyssey*, is several centuries earlier, being in the main coeval with the Third Late Minoan Period of Crete, that is *circa* 1400 to 1200 B.C. The Phæaceans repeatedly referred to in the *Odyssey* § appear to be identified with the Minoans of Crete || who, at that period, were famous for their sea-power. They lived during the transition period between the bronze and

* Montelius, *Journal of the Iron and Steel Institute*, 1900, No. II., p. 514.

† Reginald A. Smith, "A Guide to the Antiquities of the Early Iron Age" (British Museum, 1905), p. 1.

‡ Herodotus ("History," translated by Rawlinson, Book ii., Chapter 53), who was born about 484 B.C., gives it as his opinion that Homer "lived but 400 years before" his time. See also Buckley's Editorial on Pope's translation of the *Odyssey* (Warne & Co.), p. xxiii.

§ *Odyssey*, vi. 266, 270; vii. 34, 86-102; viii. 247-250, 370-380; xiv. 224.

|| See Drerup, *Homer* (Munich, 1903), pp. 130, *et seq.*; Burrows, "Discoveries in Crete" (Murray, 1907), p. 208.

iron ages, and a study of the references to these metals in the poems is full of interest.*

Iron, though not regarded as a precious metal in the sense that gold was, ranked amongst the treasures of the wealthy, and is frequently referred to in that sense. Thus, in the *Odyssey* the old wanderer, who is none other than Ulysses himself in disguise, describes to Gumeus the reputed adventures and wealth of Ulysses in distant lands. He says :†

I saw myself the vast un-numbered store
Of *steel elaborate* and refulgent ore,
And brass high heaped amidst the regal dome ;
Immense supplies for ages yet to come.

Again, Adrastus at the feet of Atreides begs his life, offering his conqueror stores of iron for ransom : ‡

Spare me, great son of Atreus ! for my life
Accept a price ; my wealthy father's house
A goodly store contains of brass, and gold,
And *well wrought iron* ; and of these he fain
Would pay a noble ransom, could he hear
That in the Grecian ships I yet surviv'd.

The expression " well wrought iron " occurs frequently

* It has frequently been urged that the Homeric poems are not the work of a single poet ; the unity of the *Iliad* has, in particular, been made the subject of controversy. In these pages the view is adopted of those scholars who suggest that in the main the poems are the work of one man whom we call Homer, although they are prepared to admit that certain additions and interpolations have been made. See Allen, *Classical Review*, vol. xix., p. 359 ; vol. xx., p. 267 ; vol. xxi., p. 16. Lang, " Homer and His Age " (Longmans, 1906). Ridgeway, " The Early Age of Greece " (Cambridge University Press, 1901). Cotterill, " Ancient Greece " (Harrap, 1913).

† *Odyssey*, Pope's translation, xiv.

‡ *Iliad*, Derby's translation, vi.

in the *Iliad*, and indicates that iron was found to be considerably more difficult to work than bronze.

Beautiful Penelope, the faithful wife of Ulysses, decides to allow the suitors, who continually press for her favour, to try their strength and bend if possible her hero husband's bow. This she fetches from the treasure-house which contains not only Ulysses' gold, but bronze and iron. In the words of the poet :*

She sought her inmost chamber, the
 Recess in which she kept the treasures of her lord,
 His brass, his gold, his *steel elaborate*.
 Here lay his stubborn bow, and quiver fill'd
 With num'rous shafts, a fatal store.

The term "steel elaborate" is, of course, a poetical translation. The metal would be iron as obtained by direct reduction of the ore in small furnaces. Derby's "well wrought iron" in the previous quotation is a very apt translation.

From the foregoing passages it is evident that iron was a well recognised commercial commodity, used just like slaves and cattle for barter as well as for the manufacture of various implements. With the regard to the former of these uses, we are told that—†

From Lemnos' isle a num'rous fleet had come
 Freightied with wine ;

and that the—

Greeks

Hasten'd to purchase, some with brass, and some
 With *gleaming iron* ; other some with hides,
 Cattle or slaves ; and joyous waxed the feast.

* *Odyssey*, Cowper's translation, xxi. For other examples see *Iliad*, ix., x., xi.

† *Iliad*, Derby's translation, vii.

The same idea is further emphasised by the passage in the *Odyssey*,* in which Pallas, disguised as Mentès, answers the queries of Telemachus, the son and heir of Ulysses. The goddess says :*

With ship and mariners I now arrive,
 Seeking a people of another tongue
 Athwart the gloomy flood, in quest of brass
 For which I barter steel, ploughing the waves
 To Temesa.

Possibly Temesa is the site of the modern town of Temasus in Cyprus, for this island was the main source of copper in early days—whence the name for copper in modern European languages.†

In any case, the inference may be drawn that iron was obtainable in sufficiently large quantities to supply ships with cargoes of it. Bearing this in mind, it is remarkable that whilst iron was used in Homeric times for peaceful implements there appears to have been no demand for its use for military purposes. This is well illustrated by the speech of Achilles on the occasion of the funeral feast in honour of Patroclus. It was customary to have trials of strength, and Achilles offered a ponderous lump of iron to him who could hurl it furthest in the contest.‡

Next in the ring the son of Peleus plac'd
 A pond'rous mass of iron, as a quoit
 Once wielded by Eëtion's giant strength,
 But to the ships with other trophies borne,
 When by Achilles' hand Eëtion fell.
 Then rose, and loudly to the Greeks proclaim'd :

* *Odyssey*, Cowper's translation, i.

† See p. 38.

‡ *Iliad*, Derby's translation, xxiii.

“Stand forth, whoe’er this contest will essay.
 This prize who wins, though widely may extend
 His fertile fields, for five revolving years
 It will his wants supply; nor to the town
 For lack of iron, with this mass in store,
 Need he his shepherd or his ploughman send.”

The last three lines suggest that there were men on the farms who knew how to work iron in a rough, primitive manner.

It must be confessed, however, that at first sight this speech appears remarkably pacific for so redoubtable a warrior as Achilles. One would rather have expected an allusion to the military uses of the metal.* As Lang† points out, however, “if iron weapons were not in vogue, while iron was the metal for tools and implements, the words of Achilles are appropriate and intelligible.” Iron hatchets and axes appear to have been quite usual tools, and Achilles at the above-mentioned funeral games offered ten double-edged axes and ten single hatchets of iron for competition. These do not appear to have been intended for military use. Indeed, it is usually agreed that the Homeric swords, spears, and defensive armour were of bronze,‡ and the Greek word for that alloy is generally employed in the poems. For example, during the fight between Ulysses and Penelope’s suitors, the poet tells us that Telemachus left the hall—

Seeking the chamber where he had secured
 The armour. Thence he took four shields, eight spears,

* Helbig, *Das homerische Epos*, 1887, p. 330.

† Lang, *Revue Archéologique*, 1906, vol. vii., p. 280.

‡ Lang, *loc. cit.* Allen, *Classical Review*, vol. xxi., p. 19. Compare Burrows, *op. cit.*, p. 214, and Ridgeway’s reply, *Proceedings of the British Academy*, 1909, vol. iv.

With four fair crested helmets, charged with which
He hastened to his father's side again,
And, arming first himself, furnished with arms
His two attendants. Then *all clad alike*
In splendid brass, behind the dauntless Chief
Ulysses, his auxiliars firm they stood.*

The word here translated "brass" would have been more correctly rendered "bronze," which is normally an alloy of copper and tin. Brass, on the other hand, is an alloy of copper and zinc, and was unknown to the Greeks. The Romans were the first to prepare it, *circa* B.C. 20, that is, some 860 years after the time of Homer. The earliest piece of brass known is a Roman coin dated B.C. 20, and containing 17.3 per cent. of zinc.† Roman brass was prepared by heating natural zinc carbonate—calamine—with charcoal in a crucible in contact with copper at a temperature below the melting point of the last named metal. The vapour of zinc liberated by interaction of the first two substances permeated the copper and produced brass. The temperature was then raised, the brass melted and cast. This method was in use in this country as late as the middle of last century, the product being known as *calamine* brass. The last brass works to produce the metal by the Roman method were not closed down in this country until about 1850.

Metallic zinc was not known to the Romans; indeed it was probably not known in Europe until the sixteenth century, the modern word "zinc" appearing first in the writings of Paracelsus, *circa* 1500.

In Greek alloys zinc is never found as an intentional ingredient, although small quantities may be present as impurities to the extent of one or two per cent.

* *Odyssey*, Cowper's translation, xxii.

† Gowland. *Journal of the Institute of Metals*, 1912, vii., 23.

It is always possible that the metal may have been produced in early times as the result of accident. It is said,* for example, that "zinc bracelets were discovered in the ruins of Cameros, destroyed *circa* B.C. 500." If these are genuine it seems almost certain they had been produced by accident. Neither brass nor zinc was known to Homer at the time that he wrote his poems, *circa* 850 B.C., the weapons referred to being made of the harder alloy, bronze.

A curious feature of the passage referred to above is the fact that, whilst the heroes are distinctly stated to be clad in bronze, Ulysses, in referring to the selfsame weapons,† had already implied that they were of *iron* by advising his son to remove them from the hall prior to the fight with the suitors, "since iron of itself attracts a man." Perhaps, however, this is a later interpolation and may have reference to the magnetic property of iron, which was regarded with a certain amount of superstition. The sentence can quite easily be deleted without altering the sense of the narrative.

On the other hand it must not be forgotten that, during transition periods and indeed for long after, the early names are retained although logically they are incorrect. Witness, for example, the term *sealing wax*, reminiscent of the time when wax was actually used for sealing postal packets, although lac replaced the wax many years ago. The Germans, always progressive in matters of detail, have substituted the now more correct term *Siegel-lac* for the earlier *Siegel-wachs*, but we English have not done so. Other examples are given on p. 35. Consequently it would be rash to conclude, from linguistic arguments alone, that the armour referred to was

* Thorpe, "A Dictionary of Applied Chemistry" (Longmans), 1913, vol. v., p. 803.

† *Odyssey*, Cowper's translation, xvi.

necessarily bronze, particularly when we have ample evidence that iron weapons were not altogether unknown at this period. We read of— *

Great Areithous known from shore to shore
By the huge, knotted *iron mace* he bore.

Again, the arrow used by Pandarus in his stealthy attempt to slay Menelaus at the bidding of Athene bore an iron head.†

At once the sinew and the notch he drew ;
The sinew to his breast, and to the bow
The *iron head* ; then, when the mighty bow
Was to a circle strain'd, sharp rang the horn,
And loud the sinew twanged, as tow'rd the crowd
With deadly speed the eager arrow sprang.

The arrow used by Pandarus was very primitive, its head being socketless. It was fastened firmly with sinew and with a tang entering the shaft.‡

It is of interest to note that on a Mycenæan silver bowl archers are represented as drawing to the breast, in the manner described above.

Iron knives were also known. They were employed, not as weapons of war, but for cutting the throats of victims, as, for example, at a funeral feast.

There many a steer lay stretched beneath the knife,
we read in connection with the funeral pyre of Patroclus.§ Bronze knives appear to have been used for this purpose also, however.

One very plausible reason for the continued use of bronze for military weapons in Homeric times is given by

* *Iliad*, Pope's translation, vii.

† *Iliad*, Derby's translation, iv.

‡ Lang, *loc. cit.*

§ *Iliad*, Derby's translation, xxiii.

Lang,* who points out that the early specimens of iron were not always reliable in quality. Owing to imperfect methods of manufacture the metal was liable to bend or buckle. It was thus unsuitable for swords where great strength was required coupled with a minimum thickness. In the case of the mace quoted above a keen cutting edge was not so necessary, the object of the weapon being more particularly to give a stunning blow. Even in this case, however, the mace is spoken of rather as a curiosity than otherwise. Lang's view is quite in harmony with the experience of the modern metallurgist.

Iron, at this period, and indeed right down until our own middle ages, was always prepared by the direct process, that is, it was reduced from the ore by heating in small charcoal furnaces. It was never melted, but obtained as a spongy product, more or less contaminated with slag, and oft-times very free from carbon. Iron containing less than 0.1 per cent. of carbon is very soft, and in thin sheets can easily be cut with ordinary scissors. A sword of this material would lose its edge even with sharpening a lead pencil! The introduction of a further small quantity of carbon, say up to 0.5 or 0.6 per cent., completely alters its properties, for it can now be tempered and given a hard cutting edge. It is most remarkable that the addition of so small a quantity of carbon should be able to modify the properties of the metal to such an enormous extent.

The early metallurgist would probably be able to tell whether or not his metal was at all likely to turn out successfully; in any case he would test his material in some crude practical manner and probably only work up those portions that appeared suitable. He would not, however, know what caused the difference, nor yet how

* Lang, *op. cit.* Also "The World of Homer" (Longmans, 1910).

to remedy it, by transforming his soft, carbonless metal into the harder, carburetted steel. He would simply know that sometimes his furnace yielded him good stuff—when the gods were pleased—and at other times, poor metal.

Lang's view receives strong, if indirect, support from several other sources. In the account given by Polybius of the Keltic invasion of Italy 223 B.C., reference is made to the poor quality of the iron used by the Kelts. The Romans inflicted on them, at the battle of Addua, near Milan, a heavy defeat, attributable mainly to the fact that the long iron swords of the Kelts were "easily bent, and would only give one downward cut with any effect, but that after this the edges got so turned and the blades so bent, that, unless they had time to straighten them with the foot against the ground, they could not deliver a second blow."*

As is indicated in the sequel, the Chinese used iron for domestic and agricultural purposes long before they employed it for military purposes, and apparently for the same reason as the Homeric heroes (see p. 196)—another case of history repeating itself amongst nations widely separated from one another, both geographically and ethnologically. The same kind of difficulty faced the warrior in Iceland more than 1,000 years later, as references in the sagas clearly indicate (see p. 99).

Speaking of the iron made by the natives of Central Africa, *circa* 1850, Livingstone † said that he had seen a javelin of iron light upon the cranium of a hippopotamus and curl up like the proboscis of a butterfly. In such

* Polybius, 205 to 123 B.C. Quoted by Ridgeway, "The Early Age of Greece" (Cambridge University Press, 1901), vol. i., p. 408.

† Livingstone, "Missionary Travels" (Ward, Lock), p. 557.

cases the owner would straighten the metal out again by hammering in the cold between two stones.

Now if the iron familiar to the Homeric heroes was as unreliable as that of the Kelts, 223 B.C., or of the Icelanders, A.D. 1000, or of the natives of Central Africa in more recent times—and the probability is that it was quite as inferior in quality—it is not surprising that bronze weapons should be preferred. For a warrior to be compelled to halt and straighten his sword on the field of battle is surely giving his opponent somewhat of an advantage.*

If, on the other hand, Homeric iron was not so poor as described above, it is nevertheless easy to understand that, unless its quality was such as to render it distinctly superior to bronze, the latter metal would be retained by military conservatism, "just as the fifteenth century soldiers found the long-bow and cross-bow much more effective than guns, or as the Duke of Wellington forbade the arming of all our men with rifles instead of muskets."† For ‡ "soldiers are naturally conservative, and are disinclined to give their confidence to a new weapon or to a new arm of the service till it has proved its worth."

The Greeks in Homeric times appear to have possessed a certain knowledge of tempering. This is hinted at in those lines of the *Odyssey*,§ which portray with graphic effectiveness the blinding of Polyphemus, the one-eyed giant, by Ulysses, who plunged a fiery stake into his orb.

* Berard, *Les Phéniciens et l'Odysée* (Paris, 1902); Lang, *Revue Archéologique*, 1906, vol. vii., p. 280.

† Lang, *loc. cit.*

‡ Major-General Maurice, *The Daily Chronicle*, August 10, 1918.

§ *Odyssey*, Cowper's translation, ix.

As when the smith an hatchet or large axe
 Temp'ring with skill, plunges the hissing blade
 Deep in cold water, (whence the strength of steel)
 So hissed his eye around the olive wood.

The question has frequently been asked whether or not the mass of iron offered by Achilles was of meteoric origin, because it is described in the original Greek as "self smelted." Ridgeway* does not consider that it could have been meteoric. "Tempting as this suggestion is," he writes, "we must bear in mind that meteoric stones have in many parts of the world, both ancient and modern, been regarded with awe and veneration. Thus, in the Greek lands and those bordering on them, meteoric stones were among the earliest objects of veneration. They were termed *βαίτυλοι*, were usually dedicated to Cronus or to Zeus, and were anointed with oil by devout persons, such as the Superstitious Man in the 'Characters' of Theophrastus. It is not easy to suppose that people who invested meteorites with such sanctity would commit so sacrilegious an act as to use them for metal."

Iron and Herodotus.—There are several allusions to the early use of iron in the "History" of Herodotus written about 450 B.C. According to Eusebius a decree passed the Athenian Assembly in the year 446 B.C., assigning a reward to Herodotus in recognition of his classical work.†

The first reference to the metal concerns King Alyattes, who ruled over Lydia, a district in Western Asia Minor, 617 to 560 B.C. After recovering from a serious illness the king sent, as was customary in those days, a handsome present to the temple at Delphi in Phocis, which was

* Ridgeway, "The Early Age of Greece" (Cambridge University Press, 1901), vol. i., p. 598.

† See "The History of Herodotus," translated by Rawlinson (Dent's Everyman's Library, 1916), Introduction, p. xii.

famous for the Oracle of Apollo, to which the city of Delphi owed its importance. His present consisted* of "a great bowl of pure silver, with a salver in steel curiously inlaid, a work among all the offerings at Delphi the best worth looking at. Glaucus, the Chian, made it, the man who first invented the art of *inlaying* steel." The Greek word *κόλλησις*, here translated *inlaying*, may perhaps really mean *welding*.

A second reference to iron is of particular interest as showing that the Spartans were not acquainted with the working of iron at as early a date as the Tegæans. Thus Lichas is stated to have travelled from Sparta to Tegea,† "and, happening to enter into the workshop of a smith, he saw him forging some iron. As he stood marvelling at what he beheld, he was observed by the smith . . ." Herodotus evidently means to imply that the working of iron was a novelty to Lichas. This occurred during the reign of Croesus, 560 to 546 B.C.—which fixes the date approximately. It is curious that Herodotus should add, a few lines further down, that "iron had been discovered to the hurt of man." The same idea runs through Homer and Virgil, whilst, as will be seen later, Pliny moralises at length in the same strain. Even Mahomet at the beginning of the seventh century A.D., appears to have held a similar view, for he is reported‡ as saying "And we have sent down IRON. Dire evil resideth in it, as well as advantage to mankind."

Apparently even in the time of Herodotus iron was regarded with a certain amount of superstitious reverence, for we read§ that the Phocæans, having

* Herodotus, Book i., Chapter 25.

† Herodotus, Book i., Chapter 68.

‡ See Rodwell's Translation of the Koran, 1861, Sura lvii., verse 25.

§ Herodotus, Book i., Chapter 165.

voluntarily determined upon exile, "dropped a heavy mass of iron into the sea, swore never to return to Phocæa till that mass reappeared upon the surface." Knowing as they did how readily the metal would corrode under these conditions, they must have regarded their vow as irrevocable. "Nevertheless, as they were preparing to depart for Corsica more than half of their number were seized with such sadness and so great a longing to see once more their city and their ancient homes, that they broke the oath by which they had bound themselves and sailed back to Phocæa."

Herodotus makes an interesting reference to the use of iron swords in honour of Mars by the Scythians.* In the words of Rawlinson's Translation, the temples erected to this god consist each of "a pile of brushwood, made of a vast quantity of faggots, in length and breadth three furlongs; in height somewhat less,† having a square platform upon the top, three sides of which are precipitous, while the fourth slopes so that men may walk up it. Each year 150 wagon-loads of brushwood are added to the pile, which sinks continually by reason of the rains. An *antique iron sword* is planted on the top of every such mound, and serves as the image of Mars. Yearly sacrifices of cattle and of horses are made to it, and more victims are offered thus than to all the rest of their gods. When prisoners are taken in war, out of every 100 men they sacrifice one, not, however, with the same rites as the cattle, but with different. Libations of wine are first poured upon their heads, after which they are slaughtered over a vessel; the vessel is then carried up to the top of the pile, and the blood poured upon the scimitar. While

* Herodotus, Book iv., Chapter 62.

† Rawlinson calls attention to the fact that these dimensions are utterly incredible.

this takes place at the top of the mound, below, by the side of the temple, the right hands and arms of the slaughtered prisoners are cut off, and tossed on high into the air. Then the other victims are slain, and those who have offered the sacrifice depart, leaving the hands and arms where they may chance to have fallen, and the bodies also, separate."

It is difficult to understand how men could ever think their gods were pleased with these disgusting orgies of blood! But even so is it. Though the details are undoubtedly exaggerated, the kernel of the story may be regarded as correct—namely, a ceremony in which an iron sword plays an important part, for this is in harmony with our knowledge of the times.

Herodotus also relates a very curious story concerning Cræsus, King of Lydia, *circa* B.C. 560. Cræsus had two sons, one of whom was deaf and dumb, whilst the other, named Atys, was a most promising young man. One night Cræsus dreamed that Atys would die by the blow of an iron weapon. This greatly distressed him, and he immediately ordered that all spears, javelins and weapons used in war should be removed from the male apartments and laid in heaps in the women's quarters, so that no harm should accidentally come to Atys through them. He also forbade his son to accompany the Lydian forces in the field, or to take part in boar hunting. This latter restriction, however, Atys took to heart, and he expostulated with his parent, saying* "Formerly, my Father, it was deemed the noblest and most suitable thing for me to frequent the wars and the hunting parties, and win myself glory in them; but now thou keepest me away from both, although thou hast never beheld in me either cowardice or lack of spirit." Cræsus then explained

* Herodotus, Book i., Chapter 37.

that he acted through fear of his dream. "Fain would I keep watch over thee, if by any means I may cheat fate of thee during my own life-time. For thou art the one and only son that I possess; the other, whose hearing is destroyed, I regard as if he were not."

Atys was naturally distressed at the news, but pointed out that if he was to die stricken by an iron weapon, it would not be a boar that would kill him. "What hands has a boar to strike with? What iron weapon does he wield? Had the dream said that I should die pierced with a tusk, then thou hadst done well to keep me away; but it said a weapon. Now here we do not combat men, but a wild animal. I pray thee, therefore, let me go with them."

So Atys went to the hunt under the care of Adrastus, a Phrygian. And Adrastus hurled his spear at the boar, but missed his aim, and the point of the weapon buried itself within the body of Atys. Thus Atys died as his father had dreamed.

This story is interesting and leads us to enquire why the fateful weapon was specifically dreamed as being of iron. Was it less noble to be killed with iron than with stone or bronze? Perhaps it was.

Herodotus makes several other references to iron, mainly in connection with Egypt and the near East. These are dealt with in their appropriate places.

Iron and Aristotle.—Aristotle,* who lived 384 to 322 B.C., and spent much of his life at Athens, states that iron was obtained in large quantities from the ironstone of Elba and from the mines of the Chalybians, near Amisus, on the southern shore of the Black Sea. He states that, in consequence of its high clay content, the ore is difficult

* See Lippmann, *Archiv. für die Geschichte der Naturwissenschaft und der Technik*, 1910, pp. 233-300; *Stahl und Eisen*, vol. xxx., p. 1099.

to melt. In discussing the metal he says :* " Iron is of great strength and very hard, though it is said that in Cyprus there are mice which are able to gnaw it."

Discussing the different varieties of iron known in his day, Aristotle states that " The best and hardest of all the kinds of iron known is that of the Chalybians, that is, steel (Chalybs), and it is obtained from iron by melting it repeatedly together with certain stones in a furnace, during which process much slag is formed and a great loss in weight occurs, on account of which the product is very costly.

" The finished steel is very hard, with a glittering surface, and resists rust ; but it is not applicable to all the purposes for which less pure iron is used. The quality is judged by the sound given out in working it on the anvil."

It is stated that a Sicilian trader, recognising the importance of iron, upon one occasion bought up the entire production from all the smelters and sold again at his own convenience to great profit !

Iron and Crete.—Until close upon the beginning of the present century Crete was regarded as an island of but little interest to the antiquary. Practically nothing was known of its prehistoric cultures, although their existence had been hinted at by some early writers—to wit, Homer, Hesiod, and Thucydides. It remained for the spade of the twentieth-century archæologist to unearth the treasures of bygone ages and to add to the known history of the world yet another chapter which, although as yet imperfect, lacks neither in romance nor in fascinating interest.

The causes leading up to the investigation of ancient remains in Crete emanated from the thrilling discoveries of Schliemann, who, in 1871, began a series of excavations

* See *Journal of the Iron and Steel Institute*, 1910, No. ii., p. 458.

at Hissarlik, the site of ancient Troy. Here he found the remains of several cities, possibly nine, superimposed one above the other, of which the sixth and the second, counting from the bottom upwards, are of special interest. The sixth has since been proved to be the Homeric city of Troy, *circa* 1500 B.C., whilst the second city, dating back to about 2500 B.C., yielded a considerable mass of treasure, including silver vessels and daggers of gold. From Troy Schliemann went to Mycenæ in Greece, where his spade revealed a civilisation evidently contemporaneous with Homeric Troy. In a similar manner other sites disclosed evidences of the same civilisation that had been hidden from the eyes of the curious for ages, and it became clear that this Mycenaean culture had at one time spread over a considerable area in that part of Europe and Asia Minor.

Where had this civilisation sprung from? None corresponding to that of the earlier second city of Troy had been discovered in Greece, and it seemed improbable therefore that the Mycenaean civilisation could have resulted purely as the product of the internal growth of that country. Careful search was consequently made for some external source, and in Crete the spade of the archæologist rapidly unfolded to eager eyes evidences of remarkable civilisations in high stages of development which, ages ago, had reached their zenith and passed away into oblivion.

Several different portions of the island have been excavated, but of all the sites Knossos is the most famous, having proved remarkably fruitful under the skilful guidance of Dr. Evans. The low knoll or tell of Knossos consists of successive series of deposits, those of the neolithic or newer stone age beginning at some $17\frac{1}{2}$ feet below the surface and extending to a total depth of about

40 feet. It is believed that these deposits would not form at a greater rate than about one metre in a thousand years, from which it may be gathered that the neolithic settlements at Knossos took place about 10,000 B.C. and continued down to 4000 or 3000 B.C. No traces of paleolithic men have been unearthed, and even the earliest neolithic remains do not indicate the most crude stages of that culture. From this it may be inferred that neolithic man migrated to Crete from some other land, possibly Africa.

Above the neolithic remains lie those of the bronze age and of the later historic Crete. The bronze period has been termed by Evans the *Minoan Age*, in honour of Minos, the legendary sea-king of Crete, mentioned by Homer* in the lines—

One city in extent the rest exceeds,
Knossus ; the city in which Minos reigned,
Who, ever at a nine years' close, conferred
With Jove himself.

Crete was at this time the predominant sea-power of the Mediterranean, and appears to have conquered and laid under tribute the islands of the Ægean Sea.† This period extended from about 4000 B.C. to 1200 B.C., during which the civilisation rose to a maximum *circa* 1500 B.C., and continued at its zenith for about fifty years, coeval with the reign of Thothmes III. of Egypt, and then decayed. The close of the Minoan Age came in 1200 B.C., about the time of the Trojan War and the fall of the sixth city of Troy, as depicted by Homer. This was the period of the transition from the bronze age to that of iron in Crete. Thus, at Kavusi on Thunder Hill in Eastern Crete, a short

* *Odyssey*, Cowper's translation, xix.

† Herodotus, Book iii., Chapter 122.

iron sword was found, together with bronze brooches and vases, transitional between Minoan and historic Crete.*

An example of peculiar interest in this connection is afforded by the Muliana Tomb in Eastern Crete.† Uncremated bones were found, together with bronze swords and other relics, on one side of the tomb, while later interments were situated on the opposite side, and comprised an iron sword and dagger, as well as cremated bones contained in a cinerary urn resembling in design early Greek vases that have been found at Athens.‡ The interesting feature consists in the fact that the earlier interments had not been plundered or cleared out, as would have been anticipated had they met the eyes of alien intruders. Evans,§ therefore, concludes that "they had been simply placed on one side in order to make room for the funeral furniture of some later scion of the same family, so that we have here the interesting spectacle of the succession of corpse burial by cremation and of iron weapons by bronze, apparently without any break in the indigenous stock."

Mosso || mentions that he excavated beneath the foundations of the Minoan Palace at Phaestos. At a depth of four metres he came across "a piece of magnetic iron weighing half a kilogram. We may suppose that this was a cultus object from the fact that it had never been used as a hammer, though from its shape it might have

* Boyd, *American Journal of Archaeology*, 1901, vol. v., p. 128. See also Lang, "The World of Homer" (Longmans, 1910), p. 97.

† Described by Xanthoudides, *Εφ' Ἀρχ.*, 1904, p. 22.

‡ Burrows, "Discoveries in Crete" (Murray, 1907).

§ Evans, *Archæologia*, 1905, vol. lix., p. 391: "Prehistoric Tombs of Knossos" (Quaritch, 1906).

|| Mosso, "The Dawn of Mediterranean Civilisation" (Unwin, 1910).

served for that purpose. I know no more ancient specimen of iron."

The earliest iron weapons in the Ægean hail from Eastern Crete. Soon afterwards they appear to have reached Thessaly and later still to have become abundant at Athens and Tiryns where iron swords have been unearthed from tenth century B.C. graves.*

Iron in Austria and Switzerland.—Important antiquarian discoveries were made, some years ago, at Hallstatt in the Austrian Tyrol, and at La Tène in Switzerland. The remains were those of the burial places of prehistoric men, those at Hallstatt having reached the transition period from bronze to iron, whilst those at La Tène were somewhat more advanced, and correspond to what is recognised as the late Celtic age in these islands, and may be regarded as an early iron age. These remains have been studied with exceptional care, and for the sake of convenience have been grouped into various types, known as the Hallstatt and La Tène periods respectively, representing definite stages of culture in the upward progress of civilisation. With these the antiquities of other countries are compared. This procedure is all the more valuable, inasmuch as different countries could not be expected in bygone ages, any more than now, to reach the same stages of civilisation at the same time. This point has already been emphasised in previous pages (see p. 28).

For Switzerland, France, and Central Europe the following dates have been suggested by various authorities corresponding to the several ages of culture : †

* See "The Cambridge Ancient History," 1924, vol. ii., p. 524.

† Adapted from R. A. Smith, *opus cit.*, p. xii.

Switzerland (Heierli, 1898).	France (Montelius, 1901).	Central Europe (Reinecke, 1902).
Early Hallstatt, 750 to 600 B.C.	Hallstatt I., 850 to 600 B.C.	Hallstatt Periods.
Late Hallstatt, 600 to 400 B.C.	Hallstatt II., 600 to 400 B.C.	La Tène A., Vth Century B.C.
La Tène I., 400 to 200 B.C.	La Tène I., 400 to 250 B.C.	La Tène B., IVth Century B.C.
La Tène II., 200 to 50 B.C.	La Tène II., 250 to 150 B.C.	La Tène C. IIIrd & IIrd Century B.C.
La Tène III. and Roman, 50 B.C. onwards.	La Tène III., 150 to 1 B.C.	La Tène D., 1st Century B.C.

The Hallstatt cemetery is situated in a defile in the Noric Alps of the Austrian Tyrol, hard by the modern village of that name. It has for ages been the scene of extensive salt mining, as its name implies, and lay within forty miles of Noreia, which gave its name to Noricum, one of the earliest centres of the iron industry in Europe. Between 1847 and 1864 excavations were diligently carried out, some 6000 objects being obtained from nearly 1000 graves. Montelius divided the Hallstatt remains into three groups, according to the shape and style of the swords, the Hallstatt I. period being the earliest, and the Hallstatt III. period transitional to the Early La Tène type. All the evidence goes to prove that in the Hallstatt period there was a gradual growth in culture, bronze being superseded by iron ; it was not a case of the

bronze workers being conquered and displaced by workers in iron.

The civilisation of La Tène presents several important contrasts to that of Hallstatt. The site of La Tène lies near Marin in a small bay at the northern end of Lake Neuchâtel in Switzerland. The gradual development of iron brooches is an interesting feature of the finds of La Tène, a ring or collar being developed for keeping the end of the pin in position in a fashion not altogether unlike the end of some modern safety-pins.

Iron in Italy.—There was in Etruria, in Italy, an advanced bronze age culture prior to 1000 B.C., and about this latter date iron swords with bronze handles are common. "From the occurrence of such advanced weapons as swords it might be contended that iron had been in use for several centuries earlier, but this contention will not hold if we remember that the men of the bronze age had already become highly skilled as workers in metal, so that, when once they had obtained a lump of iron from its ore, they would have less difficulty in fashioning it into weapons, especially swords, than they had had with copper or bronze. Hence, from the first discovery of iron until its general use, there would be no long interval of time."*

* Gowland, "Huxley Memorial Lecture for 1912," Royal Anthropological Institute of Great Britain and Ireland, p. 287.

CHAPTER VIII.

IRON AND THE ROMANS.

THE Romans were a wonderful people and had developed the metallurgical arts to a remarkably high degree. They made good use of the iron resources of their empire, and reference has already been made to the superiority of their weapons over those of the Celts in the third century B.C. Virgil,* the Roman poet, describes the smithy in full work :

A flood of molten silver, brass and gold,
And deadly steel in the large furnace rolled ;
Of this, their artful hands a shield prepare,
Alone sufficient to sustain the war.
Seven orbs within a spacious round they close,
One stirs the fire, and one the bellows blows,
The hissing steel is in the smithy drowned.

Clearly the Romans were familiar with steel and the method of tempering it prior to 30 B.C. Study of Pliny's "Natural History" reveals the fact that, at the dawn of the Christian era, the Romans possessed a truly wonderful knowledge of iron, its ores and its metallurgy. Pliny was born about A.D. 23 at Novum Comum, on the southern shore of Lake Larius, in Northern Italy. He died at the

* Virgil, *The Aeneid*. Dryden's translation (Routledge, 1884), Book VIII. The last line has been italicised by the present author. Virgil was born 76 B.C., and was at work on the *Aeneid* when about forty years of age.

age of fifty-six in A.D. 79, falling a victim to his scientific ardour in investigating that fatal eruption of Vesuvius which enveloped Pompeii and Herculaneum in disaster. His book was published two years before his death, namely in A.D. 77.

As a matter of historical interest Pliny states* that "the Cyclopes invented the art of working iron." This is but one of the legends common at various times. Pausanias attributes the discovery to Glaucus of Chios; Strabo to the Idaean Dactyli of Crete, whilst he ascribes the art of manufacturing vessels of iron to the Telchines, who inhabited Rhodes. Breaking away from legend, however, Pliny becomes more informative. After giving a short account of the more common types of ore known to him and the varieties of metal obtainable from them, he passes on to consider the tempering process. Apparently unaware of the influence of the tempering temperature, Pliny† ascribes observed differences "to the quality of the water into which the red hot metal is plunged from time to time," and states that "the water, which is in some places better for this purpose than in others, has quite ennobled some localities. . . ." He then makes the following interesting statement, to which the present author has already directed attention elsewhere:‡

"It is a remarkable fact, that when the ore is fused, the metal becomes liquefied like water, and afterwards acquires a spongy, brittle texture."

This can surely only mean one thing, namely, that the Romans occasionally obtained small quantities of cast iron, possibly by the accidental overheating of their

* Pliny, "Natural History," translated by Bostock and Riley (Bohn, 1857), Book vii., Chapter 57.

† Pliny, Book xxxiv., Chapter 41.

‡ Friend, *The Foundry Trades Journal*, 1922, vol. xxv., p. 183.

furnaces by extra draught. In that case this passage appears to contain the earliest reference to cast iron in existence. The metal in this condition would be of no use to the Romans, as they possessed no furnaces capable of remelting it for casting purposes. It would therefore either be thrown away or possibly mixed with subsequent charges and passed a second time through the furnace.

Like earlier writers, to whom attention has already been directed, Pliny * laments the fatal uses to which iron is put, for "it is with iron also that wars, murders, and robberies are effected, and this, not only hand to hand, but from a distance even, by the aid of missiles and winged weapons, now launched from engines. now hurled by the human arm, and now furnished with feathery wings. This last I regard as the most criminal artifice that has been devised by the human mind; for, as if to bring death upon man with still greater rapidity, we have given wings to iron and taught it to fly." Strange words these, to fall from the pen of a sturdy Roman admiral.†

We are reminded of one of our own generals who, during the late war, described the machine guns used at Gallipoli as inventions of the devil. Military conservatism would appear to be common to all ages.

The pronounced tendency for iron to rust is regarded by Pliny from a very novel point of view. "Nature," he writes,‡ "in conformity with her usual benevolence, has limited the power of iron by inflicting upon it the punishment of rust; and has thus displayed her usual foresight in rendering nothing in existence more perishable

* Pliny, Book xxxiv., Chapter 39.

† In A.D. 73 or 74 Pliny had been appointed *præfect* of the Roman fleet at Misenum, on the western coast of Italy, by Vespasian.

‡ Pliny, Book xxxiv., Chapter 40.

than the substance which brings the greatest dangers upon perishable mortality."

Again: "Human blood revenges itself upon iron: for if the metal has been once touched by this blood it is much more apt to become rusty."

Pliny also knew that some kinds of iron are less resistant to corrosion than others, and distinctly mentions* a species that "is more particularly liable to rust." He further states† "that there is in existence at the city of Zeugma, upon the Euphrates, an iron chain by means of which Alexander the Great constructed a bridge across the river, the links of which that have been replaced having been attacked with rust, while the original links are totally exempt from it."

This passage is not only remarkable as being a very early, if not indeed the earliest, statement of the relative corrodibilities of two kinds of iron; it is also of peculiar psychological interest in that it emphasises the unity of human nature throughout the ages. Pliny argues that even in his day the older metal was better than the new. We are involuntarily reminded of the man who complained that *Punch's* jokes are not now as good as they used to be; to which *Punch* pithily replied, "They never were."

This tendency of iron to rust was occasionally turned to good account. Thus Pliny‡ mentions that the "artist Aristonidas, wishing to express the fury of Athamus subsiding into repentance, after he had thrown his son Learchus from the rock, blended copper and iron, in order that the blush of shame might be more exactly expressed, by the rust of the iron making its appearance through

* Pliny, Book xxxiv., Chapter 41.

† Pliny, Book xxxiv., Chapter 43.

‡ Pliny, Book xxxiv., Chapter 40.

the shining substance of the copper ; a statue which still * exists at Rhodes." It must be admitted that this is a very clever metallurgical conception.

It is interesting to learn that iron, however baneful its nature, may sometimes be put to useful purpose. "For if a circle is traced with iron, or a pointed weapon is carried three times round them, it will preserve both infant and adult from all noxious influences : if nails, too, that have been extracted from a tomb, are driven into the threshold of a door, they will prevent nightmare. A slight puncture with the point of a weapon, with which a man has been wounded, will relieve sudden pains, attended with stitches in the sides or chest. Some affections are cured by cauterisation with red-hot iron, the bite of the mad dog more particularly ; for even if the malady has been fully developed, and hydrophobia has made its appearance, the patient is instantly relieved on the wound being cauterised. Water, in which iron has been plunged at a white heat, is useful, as a potion, in many diseases, dysentery more particularly." †

Superstition with regard to the medicinal value of iron has not even yet entirely disappeared. Mention has already been made of the fact that iron and steel rings are still used as a "cure" for rheumatism.

Apparently as an atonement for its murderous propensities iron, after it has rusted, is stated by Pliny to serve as a remedy in no fewer than fourteen different sicknesses or ailments. ‡ "The rust of iron is usually obtained for these purposes by scraping old nails with a piece of moistened iron. It has the effect of uniting wounds, and is possessed of certain desiccative and

* That is, of course, in Pliny's time.

† Pliny, Book xxxiv., Chapter 44.

‡ Pliny, Book xxxiv., Chapter 45.

astrigent properties. . . . Diluted in wine, and kneaded with myrrh, it is applied to recent wounds, and, with vinegar, to condylomatous swellings. Employed in the form of a liniment, it alleviates gout."

By the ancients iron was regarded as representing Mars, the god of war. The symbol ♂ was used by the early alchemists to denote this metal, and which is usually regarded as derived from the shield and spear of the god.

The common idea that iron invigorates the constitution owes its origin largely to this connection with the god of war, whose virility was assumed to be possessed by his dedicatee.

The remedial action of iron in chlorotic disease had established its reputation long before iron was discovered to be an invariable constituent of the human body. Thomas Sydenham (1624-1689) described how iron quickens the pulse and freshens the countenance and recommended the taking every morning of 8 grains of steel filings made into two pills with extract of wormwood. Next to the direct dosing with the metal he recommended "the Syrup of it prepared with filings of steel or iron infused in cold Rhenish wine till the wine is sufficiently impregnated, and afterwards strained and boiled to the consistence of a syrup with a sufficient quantity of syrup." It is stated* that a curious marriage custom was at one time common at Frankfurt, in accordance with which burghers' wives were prohibited from visiting the chalybeate springs at Schwalbach more than twice in their lives, lest they should prove too fruitful! Was that, or was that not, a subtle advertisement for Schwalbach? †

According to an ancient legend Melampus was a shep-

* Wootton, "Chronicles of Pharmacy" (Macmillan, 1910), vol. i., p. 398; vol. ii., p. 309.

† *Ibid.*, vol. i., p. 403.

herd who lived *circa* 1380 B.C., and who became very skilled in medicine. King Iphiclus of Phylacea greatly desired to beget children, and was successfully treated by Melampus, who gave him iron rust in wine—the earliest *vinum ferri* of the pharmacist on record.*

With regard to the question as to whether or not the Romans were acquainted with the process of carburising steel by cementation, Stead † wrote in 1912 that “it was known that they did manufacture steel, and that it was almost certain that the carbon must have entered the iron by cementation. It was doubtful whether they practised the process as conducted in modern times, but it was easy to conceive how pieces of iron could be carburised by embedding them in the heart of a large charcoal fire and maintaining them at a high temperature by using blast insufficiently strong to penetrate to the centre of the hearth. The combustion of the charcoal near the walls of the furnace in such case would maintain the iron and charcoal at a sufficiently high temperature to admit of any degree of carburisation required.”‡

In order to retard corrosion, Pliny recommended the application of a mixture of lead carbonate, gypsum, and tar. “Some pretend, too,” he adds, “that this may be ensured by the performance of certain religious ceremonies,” but he himself evidently shared no such illusions.

Macaulay in his beautiful *Lays of Ancient Rome*, avails himself to the full of customary poetic licence. The scene described dates back to about B.C. 360. Horatius,

* *Ibid.*, vol. i., p. 12.

† Stead, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 133.

‡ Further particulars of Roman iron in Europe with analyses and micro-graphs are given by Neumann, *Zeitschrift für Elektrochemie*, 1923, vol. xxix., p. 175.

with his two supporters, was holding the bridge over the Tiber against the combined forces of the Etruscans, when Astur rushed against him, and,

“ Smote with all his might.
With shield and blade Horatius
Right deftly turned the blow.
The blow, though turned, came yet too nigh ;
It missed his helm, but gashed his thigh :
The Tuscans raised a joyful cry
To see the red blood flow.

“ He reeled, and on Herminius
He leaned one breathing space ;
Then, like a wild cat mad with wounds,
Sprang right at Astur’s face.
Through teeth, and skull, and helmet
So fierce a thrust he sped,
The good sword stood a hand-breadth out
Behind the Tuscan’s head.

.

“ On Astur’s throat Horatius
Right firmly pressed his heel,
And thrice and four times tugged amain,
Ere he wrenched out the *steel*.”

and this, after the self-same sword had already felled Picus of Clusium, and pierced the heart of Lausulus ! Probably Horatius wielded a short bronze sword, for men had already learned that by repeated cold working bronze could be rendered extremely hard and serviceable. The term *steel* therefore must not be taken too literally—neither must the story !

CHAPTER IX.

IRON AND THE VIKINGS.

MENTION has already been made of the fact that in early Viking days, *circa* A.D. 800 to 1100, the quality of the iron used was liable to vary, so that the swords could not always be relied upon in battle. "The "Story of the Ere-dwellers," a famous saga, which deals mainly with the life of Snorre the Priest (A.D. 963 to 1031), affords an apt illustration. The sagas are largely devoted to accounts of family squabbles, and, referring to one of these, the story reads :* "So then befell a great battle, and Steinthor was at the head of his own folk, and smote on either hand of him ; but the fair-wrought sword bit not whenas it smote armour, and oft he must straighten it under his foot." This was evidently made the subject of joking, for the following year, when engaged in another quarrel, Steinthor drew his sword, and one Thorleif Kimbi called out in derision, "I wot not if thou raisest yet again a soft brand withal, as thou didst last autumn at Swan-firth," to which Steinthor replied lustily, "I will that thou prove ere we part whether I bear a soft brand or not." His sword was of good metal this second time, however, for not only did Steinthor carve off Thorleif's leg neatly at the knee, but cut another man asunder

* "The Story of the Ere-dwellers," translated by Morris and Magnússon (Quaritch, 1892). The Saga Library, vol. ii.

above the hips, without needing to stop and straighten out the metal.

In September, 1000 A.D., there was a great sea battle between Olaf Trygvesson, King of Norway, and Swend, King of Denmark—the father of Canute—in which Olaf lost his life. During the course of the struggle Olaf* “looked down over the ship’s side, and saw that his men struck briskly with their swords, and yet wounded but seldom. Then he called aloud, ‘Why do ye strike so gently that ye seldom cut?’ One among the people answered, ‘*The swords are blunt and full of notches.*’ Then the king went down into the forehold, opened the chest under the throne, and took out many sharp swords, which he handed to his men; but as he stretched down his right hand with them, some observed that blood was running down under his steel glove, but no one knew where he was wounded.”

At the battle of Nessie between King Olaf the Saint and Swend of Denmark in 1016, the fortunes of war were reversed, the victory falling to the Norwegians. Olaf had 100 men in his ship armed with coats of ring mail, that is, a network of iron rings either sewed upon a stout shirt of leather (or wool) or, less often in the early days, interlinked amongst themselves—chain mail. Some of the former are on view at Copenhagen in the Museum of Northern Antiquities. Sigvat the Scald, who was himself in the fight, on Olaf’s side, afterwards composed a lay known as the Nessie Song, in the course of which he says : †

* See “King Olaf Trygvesson’s Saga,” by Snorre Sturluson. Translated by Laing, Chapter cxix.

† See “Saint Olaf’s Saga,” by Snorre Sturluson. Translated by Laing, Chapter xlviii.

"The shields we brought from home were white,
Now they are red-stained in the fight :
This work was fit for those who wore
Ringed coats of mail their breast's before.
Where the foe blunted the best sword
I saw our young king climb on board.
He stormed the first : we followed him—
The war-birds now in blood may swim."

The war-birds referred to in the last line are the ravens, which were regarded as specially sacred to the god Odin.

The ring mail, however, was not a perfect protection against good weapons wielded by powerful men. In 994 a severe battle took place between Earls Hakon and Eric of Norway and the Jomsburg Vikings. These latter were well known and feared for their great strength and ferocity. During the fight* "so many spears were thrown against Earl Hakon that his armour was altogether split asunder, and he threw it off. So says Tind Halkelson :—

'The ring-linked coat of strongest mail
Could not withstand the iron hail,
Though sewed with care and elbow bent,
By Norna, on its strength intent.
The fire of battle raged round,—
Odin's steel shirt flew all unbound !
The earl his ring-mail from him flung ;
Part of it fell into the sea,—
A part was kept, a proof to be
How sharp and thick the arrow-flight
Among the sea-steeds in this fight.' "

Norna, referred to in the fourth line of the above, was one of the Fates, but refers to the women who used to sew the rings on to the shirts to make the mail.

* See "King Olaf Trygvesson's Saga," Chapter xliii,

In the Laxdale Saga* an account is given, amongst many other events, of the heroic death of Kjartan, whose experience in his last fatal fight was similar to that of Steinthor referred to above. Kjartan was an Icelfander who, during one of his visits to Norway, had a wrestling match with Olaf Trygvesson, King of Norway, when bathing in the sea. His prowess in the water was such that the king took a great fancy to him and made him an honoured member of his court. When the time came for Kjartan to return to Iceland, the king presented him with a sword which "was a most noble keepsake, and much ornamented." On account of its high quality this sword was the envy of many in Iceland, and was eventually stolen and hidden in a ditch. Although Kjartan subsequently recovered it uninjured, the scabbard was never found again. Kjartan wrapped it in a cloth, laid it in a chest and apparently never used it again. This was to cost him dear, for, a year later, namely A.D. 1003, he became involved in a family squabble and with but two companions, encountered nine enemies in the dales. The saga writer remarks that Kjartan "held not the king's-gift." Nonetheless he "smote hard, *but his sword was of little avail and bent so ; he often had to straighten it under his foot.*" Ultimately he received his death blow from Bolli, who wielded a famous sword known as the "Foot-biter" or "Leg-biter." This, we are told, "was a great weapon and good, with a hilt of walrus tooth, with no silver on it ; the brand was sharp, and no rust would stay thereon."

Evidently the well known tendency of iron to corrode was a source of anxiety to the Viking warrior, just as it presents serious problems to the navy of to-day.

* See "Laxdaela Saga." Translated by Muriel Press (The Temple Classics, Dent), 1899.

When a sword had once been proved to be thoroughly good and reliable, its value was priceless. Upon the death of its owner, the sword was not usually buried in the warrior's grave, save when no man sufficiently worthy to wield it could be found, but taken by his conqueror or his next of kin for future use. Thus the weapons were christened with suggestive names, and developed a sort of life-history, which is sometimes recounted in the sagas. A good example of this is afforded by the *Laxdale Saga** which tells of one, Giermund Roar by name, a Norwegian, a "Mighty man and wealthy, and a great Viking; he was an evil man to deal with." He and his wife Thured "did not get on very well together, and little love was lost between them on either side." Giermund decided to return to Norway from Iceland, A.D. 978, and leave his wife and little daughter, Groa, behind. Although a man of considerable wealth he would leave them no money, or means of maintaining themselves, and boarding his vessel sailed down the river to the open sea. The fates were against him, however, and for a fortnight he lay becalmed by an islet not far from the main land. One night, Thured angered at being thus deserted, called her father's house-carles and bade them row Groa, who was now about one year old, and herself out to her husband's ship. Arrived thither "she went across the gangway into the ship where all men were asleep. She went to the hammock where Giermund slept. His sword 'Foot-biter' hung on a peg pole. Thured now sets the little maid in the hammock, and snatched off Foot-biter and took it with her. Then she left the ship and rejoined her companions. Now the little maid began to cry, and with that Giermund woke up and recognised the child, and

* See "*Laxdaela Saga*." Translated by Muriel Press (*The Temple Classics*, Dent), 1899.

thought he knew who must be at the bottom of this. He springs * up wanting to seize his sword, and misses it, as was to be expected,† and then went to the gunwale, and saw that they were rowing away from the ship." He ordered his men to jump into a small boat and give chase, but when they did so they began to sink for Thured's men had bored a hole in it to render pursuit impossible. Giermund then called after his wife and begged her to give him back his sword and fetch little Groa, promising her in return as much money as she would like. But Thured was not to be influenced by promises of wealth. She returned to her father's house and presented the sword to her cousin Bolli, "for she loved him in no way less than her brothers." It was this same sword, Foot-biter, with which Bolli, twenty-five years later, gave Kjartan his death-blow in the manner already described.

Foot-biter was evidently a first class sword and performed wonders in the hands of Bolli when he, in his turn, was beset by avenging foes, headed by An. We read that "An went into the dairy hard and swift, and held his shield over his head, turning forward the narrower part of it. Bolli dealt him a blow with Foot-biter, and cut off the tail-end of the shield, and clove An through the head down to the shoulder, and forthwith he gat his death. Then Lambi went in; he held his shield before him, and a drawn sword in his hand. In the nick of time Bolli pulled Foot-biter out of the wound, where-at his shield veered aside so as to lay him open to attack. So Lambi made a thrust at him in the thigh, and a great wound that was. Bolli hewed in return, and struck Lambi's

* This rapid change from the past tense to the present and *vice versa* is characteristic of the sagas, which are delightfully primitive and graphic in style.

† Note the quaintness of this remark—childlike in its simplicity.

shoulder, and the sword flew down along the side of him, and he was rendered forthwith unfit to fight. . . .” And so the fight went on, until Helgi rushed at Bolli with a spear, the head of which was an ell long, and the shaft bound with iron. The spear went through both shield and man, and Bolli’s hours were numbered.

Despite the fierceness of the encounter, Foot-biter does not appear to have bent or given way. It was carefully preserved until Bolli’s posthumous son, Bolli Bollison, was strong enough to wield it. This he was able to do at an early age, and in 1019, when but in his twelfth year, he used it to avenge his father by dealing Helgi his death-blow. During the remainder of his career Foot-biter was his everpresent companion.

In the *Grettir Saga* an account is given of the spoliation of the tomb or “howe” of Kar the Old in Norway, by Grettir the Strong, one of the most muscular men Iceland ever produced. Amongst the treasure was a short sword which Grettir held to be finer than any weapon he had ever seen, and he expressed a keen desire to possess it.*

“ In the dismal tomb

I have captured a sword, dire wounder of men.

Would it were mine ! a treasure so rare

I never would suffer my hand to resign.”

The treasure belonged of right to Thorfinn, Kar’s son, who stated that never in his father’s time had he been held worthy to have the sword, and he would only give it to Grettir after this latter hero had displayed his prowess in some way. This Grettir soon did, saving Thorfinn’s household from an attack by marauding pirates whilst the bondi was away from home. Upon Thorfinn’s return,

* See “The Saga of Grettir the Strong.” Translated by G. A. Hight. Chapters xviii. and xix. Grettir was born in Iceland about A.D. 996.

Grettir received the coveted sword in recognition of his services, and kept it to his dying day.

The final chapters of the Grettir Saga deal with the adventures of Thorsteinn Dromund, the elder half-brother and avenger of Grettir. This man joined the Varangian Guards at Constantinople, as did so many Norsemen at that time, under the leadership of Harold, the son of Sigurd, known to Englishmen in later years as Harold Hardrada, who was slain at Stamford Bridge in 1066. The Saga states that the guard were ordered on field service, and the custom on such occasions demanded that, prior to marching, a review must be held for the inspection of weapons. Particular attention appears to have been paid to the condition of the swords. Thorbjorn Angle, the Slayer of Grettir the Strong, had also joined the guard, and was the first to show his weapons. He presented his sword Grettisnaut, which he had snatched from the dead Grettir, and was none other than the famous short sword which Grettir had taken from Kar's howe many years previously. All examined it closely and marvelled at its texture. Its edge, however, was not perfect, but lacked a piece which had broken away when Angle vented his ignoble rage upon the dead Grettir by hewing at his skull. Angle was in the act of boasting of his own heroism when Dromund drew near and killed him on the spot.

The object of the review would appear to ensure that every warrior had reliable weapons, so that in the field no man should be placed at a disadvantage through his sword bending or snapping in two.

It might be surmised that to men accustomed to handle doubtful weapons such as these the expression, so common to-day, "true as steel," might be regarded as a very doubtful compliment!

A mace, hammer, or battle-axe would in general, be a more formidable implement of war than a sword, inasmuch as its edge would be less easily turned, and there was less danger of its bending out of shape or snapping during an encounter. Perhaps this had something to do with Thor's predilection for a hammer.

The Scandinavian god, Odin, the patron of ravens, had several sons, one of whom was Thor, whose name is perpetuated in the Thursday or Thor's Day of our calendar. Thor was the strongest of the gods, powerfully knit together, and possessed of a red beard. He is usually represented with an iron mace or hammer, called *Mjölner*, the forging of which was the work of the dwarves, *Sindri* and *Brokkr*. *Sindri* laid iron on the hearth of his smithy and bade his brother blow, but warned him that the work would be spoiled if he ceased blowing for one moment. The work was proceeding merrily and was almost complete when a fly, sent by the malignant fire-god *Loki*, settled between *Brokkr*'s eyes, and stung him so badly that the blood fell into them and he could not see. He stopped his bellows for one moment, and, as swiftly as he could, swept the fly from him. *Sindri* came up in alarm and removed the metal from the fire in the shape of a hammer, but found that it was not seriously injured, though the haft was rather shorter than was intended. So *Brokkr* took * "the hammer to Thor, and said that Thor might smite as hard as he desired, whatsoever might be before him, and the hammer would not fail ; and if he threw it at anything, it would never miss, and never fly so far as not to return to his hand ; and if he desired, he might keep it in his sark, it was so small ; but indeed it was a flaw in the

* *The Prose Edda*, by Snorre Sturluson. Translated by Brodeur (Scandinavian Classics, vol. v., 1916), p. 147.

hammer that the fore-haft was somewhat short." Truly a regal weapon !

Owing to this uncertainty of the quality of the metal, a really good and well-proved iron sword was not only regarded as an exceptionally valuable weapon, but divine or supernatural powers were frequently attributed to it. This is well exemplified in the Laxdale Saga by the good sword Skofnung. Grim had murdered the son of Eid, and was, in accordance with the law of the times (*circa* A.D. 1018), outlawed to the mountains. Eid was old and could not well take the matter up, so Thorkell, a man of high birth and renown, offered to go and find Grim and slay him, provided Eid would give him Skoffnung, "for then," said he, "I ween I shall be able to overcome a mere runagate, be he never so mighty a man of his hands." To this Eid agreed, and in bestowing the coveted weapon, explained its wonderful powers. Said he, "the nature of the sword is such that the sun must not shine upon its hilt, nor must it be drawn if a woman should be near. If a man be wounded by the sword the hurt may not be healed, unless the healing-stone that goes with the sword be rubbed thereon." Thorkell kept the sword till his dying day. Early in 1026 his boat was overturned in a squall, Thorkell was drowned and all his men with him. The good sword "Skoffnung stuck fast to the timbers of the boat, and was found in Skoffnungs-isle"—whence the name.

Again, we read in the Njal Saga* that "Hallgrim has a bill which he had made by seething spells; and this is what the spells say, that no weapon shall give him his death-blow save that bill. That thing follows it too that it is known at once when a man is to be slain with that bill, for something sings in it so loudly that it may be

* "The Story of Burnt Njal," translated by Dasent, chapter xxx.

heard a long way off—such a strong nature has that bill in it.” This “bill” or battle-axe, was undoubtedly of extra good quality, and became the envy of many. Gunnar, one of the chief characters in the early part of the Njal Saga, and one of the manliest and finest of Icelandic heroes, coveted it exceedingly, his own bill being of but inferior metal. This is well shown by the graphic description of the duel between Gunnar and Hallgrim: “Hallgrim thrust at him with his bill. There was a boom athwart the ship, and Gunnar leapt nimbly back over it. Gunnar’s shield was just before the boom, and Hallgrim thrust his bill into it, and through it, and so on into the boom. Gunnar cut at Hallgrim’s arm hard and lamed the forearm, but *the sword would not bite*. Then down fell the bill, and Gunnar seized the bill, and thrust Hallgrim through.”

A curious passage occurs in the Cormac Saga.* A man called Stanhere, one of the leading characters in the Saga, was accustomed to carry a sword called *Scryme*, of which it was said that “it was never rusty, although there was no nicety about it.”

Why did not the iron rust? We can easily understand the Icelfander regarding it as spell-bound or divine, and are quite prepared to read, as we do further on, that wounds caused by *Scryme* healed slowly.

Probably, however, the Vikings—using this term in its widest sense—were no better smiths than the Romans in Britain. If the sword consisted of a core of iron, surrounded by a hard mass of ferroso-ferric oxide, produced by oxidation of the heated metal when being fashioned, it certainly would not rust. We know that this was the case with many Roman nails, etc., found in Britain, and

* See “*Origines Islandicæ*.” Translated by Vigfusson and Powell (Clarendon Press, 1905), vol. ii.

a weapon of that character could have no "nicety about it." Even though polished its surface would lack the true metallic lustre.

This explanation is quite in harmony with another statement in the same Saga, concerning the sword *Shavening*. This weapon was wielded by Cormac himself. in a fierce duel with Berse at Battle-holm. In the course of the duel Cormac struck at his opponent, who deftly caught the blow on his shield. Sparks flew, for the shield was iron-rimmed, and a piece was chipped out of the good sword *Shavening*. Worse still, when, after the duel, Cormac tried to whet his sword even again, "the more they whetted it down, the bigger the gap grew."

Of course this was due to enchantment. Cormac had offended the presiding genius of the sword; does not the Saga say that, prior to the duel, he had attempted to draw it when the sun was shining on the hilt? And this he had been expressly forbidden to do!

To the modern scientific mind, however, no such supernatural agencies are necessary. The chipping of the sword was to be expected if the outer layers were merely oxide, and during subsequent whetting the gap would naturally tend to widen as, under the hammer, the brittle oxide flaked away. The method of whetting would undoubtedly be closely similar to that employed to-day, as witnessed by the present Author, in remote country districts in Iceland. It simply consists in beating out the edge of the tool or weapon with a hammer on an improvised anvil. The process is slow and primitive, and clearly can only succeed when the material is malleable, which ferroso-ferric oxide certainly is *not*, despite its metallic appearance.

According to Scandinavian tradition there was constant friction between the gods. Loki, the fire-god, delighted in

mischievous, and insulted the dwarves Brokkr and Sindri, the latter of whom was the most famous of smiths. In revenge Brokkr induced Thor, the most powerful of all the gods, to hold Loki, whilst he administered suitable punishment. His first intention was to cut off Loki's head; but, dissuaded from this, Brokkr* "took a thong and a knife, and would have bored a hole in Loki's lips, and stitched his mouth together, *but the knife did not cut.*"

Although the Saga does not definitely say so, the knife of the dwarf is presumed to be of iron, for a different metal would surely have ill become the brother of a smith. That the gods themselves should have been inconvenienced by tools that would not cut, suggests a very frequent occurrence of this disability on earth.

The use of arrows with hooked or barbed iron heads appears to have been known to the Vikings. In Snorre's account† of the fierce land battle in 1030 A.D., in which perished Olaf the Stout, afterwards known as Olaf the Saint, we read of one Thormod, who fought for the king and was struck by an arrow in the left side. He promptly broke off the shaft but left the head inside the wound, and retired from the fight. Finding his way to a house hard by he lighted upon a woman who was busily engaged in binding up the wounds of the injured. His ghastly paleness attracted her attention and she asked to see his wound that she might bind it. "Thereupon Thormod sat down, cast off his clothes, and the girl saw his wounds, and examined that which was in his side, and felt that a piece of iron was in it, but could not find where the iron had gone in. In a stone pot she had stirred together leeks and other herbs, and boiled them, and gave the wounded

* "The Prose Edda," by Snorre Sturluson. Translated by Brodeur. Scandinavian Classics, vol. v., 1916), p. 147.

† See "Saint Olaf's Saga," *opus cit.*, chapter ccxlvii.

men to eat of it, by which she discovered if the wounds had penetrated into the belly; for if the wound had gone so deep, it would smell of leek. She brought some of this now to Thormod, and told him to eat of it. He replied, 'Take it away, I have no appetite for broth.' Then she took a large pair of tongs, and tried to pull out the iron; but it sat too fast, and would in no way come, and as the wound swelled, little of it stood out to lay hold of. Now said Thormod, 'Cut so deep in that thou canst get at the iron with the tongs, and give me the tongs and let me pull.' She did as he said. . . . Then Thormod took the tongs, and pulled the iron out; but on the iron there was a hook, at which there hung some morsels of flesh from the heart—some white, some red. When he saw that, he said, 'The king has fed us well. I am fat even at the heart-roots:' and so saying he leant back, and was dead."

This is an interesting passage for several reasons. To the wounded warrior the crudest of medical aid was usually meted out; but the agony was borne with heroic hardihood.

The ordeal of red hot iron was practised by the Vikings, by which it was thought possible to establish the innocence or guilt of a suspected party. The accused held the heated metal in his bare hand for a given length of time, and according to the rapidity or otherwise with which the burn was healed, as decided by the officiating priest, so was the innocence or guilt of the suspect determined. There is a distinct reference to this in Saint Olaf's Saga.* In 1026 Sigurd Thorlaksson, a Faroëse Viking, was accused by Olaf of murdering one of his countrymen. But he denied the charge and urged, "I am ready to clear myself, and my whole ship's crew, of this act, and to

* *Opus cit.*, chapter cxlv.

make oath according to what stands in your laws. Or, if ye find it more satisfactory, I offer to clear myself by the ordeal of hot iron." Olaf accepted the offer, but the ordeal was not carried out because Sigurd and his crew escaped in their ship at dead of night and returned home to the Faroe Islands.

In King Olaf Trygvesson's Saga a description is given of the ship used by Earl Eric of Norway when upon his Viking cruises about the year 1000 A.D. It is described* as having "an iron beard or comb above on both sides of the stem, and below it a thick iron plate as broad as the combs, which went down quite to the gunnel." Probably this was a series of spiked iron plates fastened round the sides and stern of the vessel to prevent boarding. Apparently it was an unusual device or it would hardly have received such special mention in the saga.

No doubt much of the iron used by the Icelandic Vikings was obtained either as booty from marauding expeditions, or by more peaceful barter, for Iceland possessed neither large supplies of fuel nor great mineral wealth. With regard to the former, it is evident that in Viking days there were numerous woods or forests in Iceland, as these are frequently referred to in the Sagas, although the trees were relatively small, many of them being no more than shrubs. Iron ore occurs, but is poor in quality; the Vikings appear to have used up most of the richest beds, and for smelting the metal cut down the forests for fuel, and these have not been replanted. In the *Landnáma-Bók* it is stated that the first man to smelt iron ore in Iceland was called Red-ore Biorn.†

* See "King Olaf Trygvesson's Saga," by Snorre Sturluson. Translated by Laing, chapter cxi.

† See "Origines Islandicæ," by Vigfusson and Powell (Clarendon Press, 1905), volume i., p. 49. These authors translate the Icelandic word *blása* as "to forge"; it is more correctly rendered "to smelt" as above.

Gustafson* gives an interesting account of the famous Oseberg Ship, which was found in a barrow at Oseberg *ødegården*, in the parish of Slagen, the ecclesiastical district of Sem in the province of Jarlsberg and Larvik. It was customary in Viking times to bury the dead in a boat or ship which was sunk into the earth and covered with a mound. This particular ship owes its remarkable state of preservation mainly to the fact that it had been buried in clay and covered with peat. It has now been restored and presented to the University Collection of Antiquities at Oslo (Kristiania). The ship is entirely of oak; the timbers had become crushed or bent out of shape to a considerable extent, but are so well preserved that it was found possible to steam them back into their original shapes. The beams are riveted together and in the restored boat two-thirds of the rivets are the original metal. "Under the prow is now hung the unusually well-preserved iron anchor, the first anchor of the Viking time that has been found. It appears rather small for the size of the ship. . . . From the ornament and other things, the time of the ship can be fixed at about the year 800. It is thus now 1100 years old."

This description fully supports the conclusion already arrived at (see p. 76), namely, that although iron was very useful when employed in relatively thick and heavy pieces, such as bolts and anchors, it was, from imperfections in manufacture, somewhat uncertain when beaten into thin strips for swords.

* Gustafson, "The Oseberg Ship" (Oslo), 1912. Printed by Brøgger.

CHAPTER X.

IRON IN BRITAIN.

It seems to be pretty well established that iron was known to the Britons at least two centuries before our era, and possibly at an even earlier date. The problem as to the original home of this early iron trade has been much discussed, and South Wales has been suggested.*

"No furnaces of the earliest period have been discovered; and it is therefore probable that the ancient Britons employed the simple low hearth resembling the Catalan furnace of the Pyrenees, which has been in use there from very remote times to our own day. The source from which Britain derived the furnace and art of extracting iron from its ores, seems to have been the Mediterranean region, either the Eastern Pyrenees or North-West Italy; but it may also be reasonably held that the first iron furnace of the Britons was derived from that used so successfully in the extraction of tin. It is not, however, probable that our islands were the earliest centre for the metal."†

Gloucestershire contributed much, and so extensive were the Roman iron works in this country that, during the sixteenth and following centuries, the slags left from their furnaces were worked again for iron by the ironmasters of those times, to save the labour of digging for ore.

* Wilkins, "The History of the Iron, Steel, Tinplate and other Trades of Wales," (Merthyr Tydvil, 1903).

† R. A. Smith, "A Guide, etc.," p. 4.

Sussex, too, was another important home of the iron industry in Roman and perhaps also in pre-Roman times. Quantities of slag, known technically as *cinders*, were left in various places and at one time were in demand for the repair of roads. That the term cinder is not modern is evident, not only from its appearance on early documents, but from the names of many early sites such as Cinderford, Cinderhill, etc.

The Britons at the time of the Roman conquest were famous for their chariots of war, drawn by two horses abreast, with a pole between them, along which the charioteer would on occasion run, even with the horses at full gallop. It is stated that the Britons who opposed Julius Cæsar had some 4,000 of these chariots. When a British chieftain died he was frequently buried in his chariot together with his horses and their equipment. Remains of these chariot burials, as they are called, have been found in different parts of the country, notably in the East Riding of Yorkshire. The wooden parts of the chariots have of course long since mouldered away, but fragments of the iron rims of the wheels have remained, sufficient to show that the wheels were originally nearly 3 feet in diameter. In some cases, too, iron mirrors have been discovered! The modern practice of fitting motors with mirrors to enable the driver to see what is going on behind would thus appear to be merely the resuscitation of a device used 2,000 years ago by the British charioteer. Well may one ask if there is anything new under the sun!

It is interesting to note, by the way, that Marco Polo in his Eastern travels during the latter half of the thirteenth century states that he visited a great city, Cobinham, where steel looking-glasses were made.*

It is very doubtful if the British chariots were fitted

* See "*Voyages and Travels of Marco Polo*" (Cassell, 1886), p. 40.

with scythed axles, as was at one time believed, for the purpose of laming hostile infantry. Such chariots might easily lame their own troops too. Boadicea is represented in the statue on the Thames Embankment as riding in a scythed chariot, but Cæsar, who saw the scythed chariots in Pontus in B.C. 47, would hardly have failed to mention the fact had he encountered them or even heard of them in Britain.

"A thick, curved blade, 6 inches long, with a stout tang of quadrangular section nearly 17 inches in length, was found with an iron wheel-tyre, a dagger, sickles, tools, and chains, at Bigbury camp, near Canterbury, but was probably the coulter of a plough. A similar iron object has been found in the marsh-village of Glastonbury, and scythe-like blades are known from Ham Hill, Somerset, and Bokerly Dyke, Wiltshire; but no actual scythed wheel has come to light."* Archæology is thus silent on the subject, and for the present it may be assumed that scythed chariots were not used by the British.

Wookey Hole.†—Within two miles of the city of Wells, carved out of the limestone rocks by natural agency, lies one of the most famous of the Somerset caves, known as Wookey Hole. In the so-called Hyæna Den hard by, which was explored by Boyd Dawkins and others in 1859, were found remains of Paleolithic man. Indeed, this was the first of all Mendip caves to yield traces of early man, and among the first in great Britain in which implements were discovered under conditions that rendered it impossible to doubt that early man co-existed with the extinct mammalia of that period. On the slopes around

* R. A. Smith, "Guide to Early Iron Age Antiquities" (British Museum, 1925), p. 11.

† Herbert E. Balch, "Wookey Hole, its Caves and Cave Dwellers" (Oxford University Press, 1914).

the caves numerous stone implements of later date have been found, classed as relics of the neolithic or new stone age; whilst from under the floor of the great Wookey Hole itself, Balch and his collaborators have unearthed pottery, and implements in stone, bronze, iron, and bone, relics of an occupation that commenced during the early Iron Age, and terminated only at the time that the Romans withdrew their forces from Britain.

Examination of the early layers constituting the floor showed that the Roman remains could be fairly readily distinguished from the lower pre-Roman layers by the dark appearance of the former, approaching almost to blackness as if from the use of coal. The pre-Roman deposit was largely that of grey wood ash.

The question now arises as to the origin of the people who inhabited these caves. From internal evidence Balch concludes that they were akin to, and contemporaneous with, the dwellers in the Glastonbury Lake Village. They appear to have come by sea from the Continent, but penetrated slightly farther inland than the lake dwellers, and made Wookey Hole their home, within the recesses of which they could successfully resist any raids from hostile tribes. They would thus share with the Glastonbury and Worlebury men the honour of having been among the first to introduce iron into England, if, indeed, it was not an independent British discovery.

In all, more than 60 iron objects have been found in Wookey Hole, dating from Roman and pre-Roman times. In general their state of preservation is excellent.

Amongst the pre-Roman relics is the dagger shown in Fig. 3, known as the Goat-herd's dagger.

It is believed to have belonged to an early goatherd, the remains of whose skeleton together with those of some goats were discovered. The dagger was accompanied

by a broken and ornamental fragment having a tang, whilst found in the same place, and almost certainly belonging to it, is a bronze mount with which its wooden handle terminated.

Another curious relic is shaped like a sickle, but possesses a ring through the loop of iron at the end of the handle, which, however, is rendered rigid with stalagmite. "The general resemblance to the latch-lifter or latch-key, specimens of which have been found in the Glastonbury Lake village, and the purpose of which was to lift a concealed latch in a palisade, makes it probable that the cave entrance was at that time thus protected."*

A very interesting find was the shoe of an ox, which animal the cave dwellers apparently "used for burden or



Fig. 3.—The Goatherd's Dagger, Wookey Hole.

draught; it will be of interest to note that the early workmen made the holes for the nails in exactly the same form as the farrier of to-day uses for his horse shoes. It is possible that the beast used was the small *bos longifrons*, the hoof bones of which correspond closely with this shoe in size." Connected with this was a possible shoe that "may have belonged to the sturdy little Keltic pony, and here again the hoof bones from our excavation agree. On the other hand this specimen is not perforated, and it does not follow the usual plate-like form of early shoes, hence it may not be a shoe at all, but an ornament of some kind."

* Balch, *opus cit.*, p. 85.

A Keltic saw was found along with its handle of cleft antler. It is interesting from several points of view. To begin with, the teeth are inclined in the opposite way to that with which we are familiar for hand saws, so that the user had to draw the tool towards him instead of the reverse. "A very interesting detail is the fact that, though these saws were thick and we should say rather clumsy in consequence, the prehistoric workman had discovered how to set them with the alternate teeth in opposite directions, just as we do to-day."

The discovery of a complete sickle is of special interest, for not only does it give the form of these implements, but also indicates "that our cave people, long before the Roman conquest, grew grain upon the land surrounding their habitations. Indeed, when to this evidence is added that of the charred grain found in the floor refuse in the Cave, there is no doubt whatever of the fact. The little sickle was obviously designed to sever the ears of the corn, probably as they were gathered in the hand, so that the straw was left standing. The ears may have been placed in a basket-work receptacle, and conveyed to the cave. The socket with which the handle of the implement terminates, evidently received a short wooden handle. A similar sickle was used in Saxon times for cutting thistles, a long handle being attached. Sickles of somewhat this form, and larger, have been found at Glastonbury, and on many sites of Early Iron Age, both Continental and British. They have also occurred in bronze in the turbaries, not far from the Lake Village, and even some hollow-edged implements of flint have been supposed to have served the same purpose, in more ancient days."

Reference is made to the brooches and currency bars found in Wookey Cave on pp. 47 and 55.

Glastonbury.*—During the winter of 1853-4 the remains of an ancient lake-village were discovered at Obermeilen on the shore of Lake Zurich, and in ensuing years other similar remains were found not only in Switzerland but in other parts of Europe, including Great Britain and Ireland, and even as far East as Asia Minor.

From the remains it is evident that these primitive dwellings may be roughly divided into three general groups.

1. True Pile Dwellings which consist of numerous wooden piles driven into the bottom of a lake at a shallow spot, and covering the tops of the piles, which were made long enough to project above the water, with a strong platform capable of supporting small huts. Such structures were fairly common in Central Europe prior to the Iron Age, and traces of them are to be found in the lakes and turbaries of Switzerland, Austria, and Northern Italy.

2. During the Iron Age an economy of material was effected by erecting "a series of submerged wooden basements in the form of small rectangular compartments, placed a few feet apart, the sides of which were formed of horizontal beams laid one above the other, like the logs of a Swiss Châlet, but having their ends projecting for a few feet at the corners. The lowest beams rested on the lake sill, and when the structures attained the requisite height above the water the usual platform was laid across, and thus the empty spaces beneath became covered over. In the corners a few uprights were placed apparently to keep the horizontal beams in position." †

3. In Scotland and Ireland yet a third method was employed, namely, to construct what was virtually a

* See Bulleid and Gray, "The Glastonbury Lake Village" (Glastonbury Antiquarian Society, 1911).

† Munro, *ibid.*, Introductory chapter.

stockaded island by forming a firm foundation of tree trunks, soil, stones, and the like, in a lake and erecting a fort upon it. These are known as *crannogs*.

In 1892 remains of a lake dwelling were discovered by Mr. Bulleid near Glastonbury, and during succeeding years careful excavations were carried on until the work was completed in 1907. Adjoining what is now known to be the site of the ancient lake-village is shown, on early maps dating back to 1540 and 1668, a sheet of water some five miles in circumference and designated as Meare Pool. There can be little doubt that when the village was originally founded it lay on the border of, or was perhaps surrounded by, a shallow lake or marsh. It is worthy of note that the village occupies "an exceptional position in the above system of classification. Like the Swiss station it consists of a collection of huts within a lacustrine area, and was evidently well adapted for defensive purposes; but it differed from them structurally in not having the huts resting on a platform supported by piles driven into the bed of the lake or marsh. On the other hand it resembled the *crannogs* in being surrounded with a palisade and having artificial understructures of prepared timbers, brushwood, stones and earth, as a firm foundation for dwelling huts."*

The village contained some 80 or 90 huts and would be able to hold a mixed population of two or three hundred persons. It was probably inhabited for a period of 150 years, namely from about 100 B.C. to 50 A.D. The stage of culture reached by the inhabitants corresponds to the Late Keltic Age. The villagers appear to have cultivated the adjacent land and used the horse for riding and driving.

Numerous objects of iron have been discovered both on

* Munro, *loc. cit.*

the actual site of the village and also outside its border palisading.* Pieces of slag and unfinished articles of iron show that the villagers were able to work the metal for themselves. It is interesting to note that, whilst no cutting tools of bronze were found, nearly 50 per cent. of the iron objects discovered possessed cutting edges, showing that iron had displaced the softer alloy for this purpose. Apparently iron and bronze were seldom combined in any one article, notable exceptions being a horse-bit, that appears to have been plated with thin bronze, and a bowl of hammered bronze, the rim of which is tubular and strengthened by an enclosed iron rim. A similar bronze bowl and iron ring had been found at Spettisbury, Dorset, in 1858.

Amongst the iron objects from the village the Late Keltic bill hook or hedge-slasher is well represented, no fewer than eight specimens having been unearthed. The largest is 11 inches long, and the smallest $8\frac{1}{2}$ inches. One specimen was found complete with a handle of ash $12\frac{1}{4}$ inches in length, the total length of the implement being $22\frac{5}{8}$ inches. The wooden handle was kept in position by an iron rivet, and owes its preservation to having lain in the peat.

Similar bill hooks, but in general without handles, have been found elsewhere, as, for example, at Hod Hill (Dorset), Ham Hill (Somerset), Hunsbury Camp (Northants), and Wookey Hole (Somerset), to mention only a few. They have also been found occasionally on the Continent. Other objects include reaping hooks or sickles, saws, gouges, adzes, files, keys or latch-lifters, horse-bits, and other miscellaneous things, including a few weapons such as daggers, spear heads, the fragment of a sword, and knives. One of the most interesting of these objects is an

* H. St. George Gray, *ibid.*, vol. ii., chapter xi.

iron saw found in the peat outside the palisading. It is complete with its wooden handle and is in an excellent state of preservation. As in the case of the Wookey Hole specimen the apices of the teeth are set in the opposite direction to those of the ordinary modern British hand saw, which indicates that sawing was effected by drawing the saw towards the operator.

The scarcity of military weapons is remarkable. Out of a total of 109 iron objects discovered only seven can be designated as weapons of offence.

It is interesting to note that two currency bars were found (see p. 51), of unit and of double unit weight respectively; there is no trace of contact with Roman civilisation, and the barest evidence of a native British coinage, one imperfect tin coin alone having been unearthed. It is noteworthy that these coins are rarely found in the tin-producing parts of Britain.*

After the arrival of the Romans a definite iron industry was established in Britain, principally, of course, for military purposes under Roman guidance. In A.D. 120 the Emperor Hadrian founded an Arms factory at Bath, where iron from the forest of Dean was worked.

Corstopitum.—An interesting account of a bloom of Roman iron found during excavation work in the old Roman city of Corstopitum was published in 1912.† That the bloom was indeed Roman was evidenced from the facts that ‡—

* See H. St. George Gray, *ibid.*, chapter xii.

† Sir Hugh Bell, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 118. See also Louis, *ibid.*, p. 120; Stead, *ibid.*, p. 121; Forster and Knowles, "Corstopitum: Report on the Excavations in 1909" (Reid, Newcastle, 1910).

‡ Haverfield, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 133. See G. Turner, *ibid.*, p. 131.

- (a) It was found amidst purely Roman objects ;
- (b) No medieval remains had occurred anywhere on the site ; and
- (c) No iron appears to have been worked in Corbridge, the modern village close to the ancient site, in medieval times.

The site of Corstopitum " lies immediately to the west of the village of Corbridge, on the north bank of the Tyne at the point where a Roman bridge, half a mile west of that now in use, carried Dere or Watling Street across the river." The city, judging from the entire absence of coins after the year 385, appears to have been abandoned about that time. This fixes the lower limit age of the bloom. " The bloom measured 39 inches between the extremities of the metallic portion ; its diameter at the widest part was 7 by 8 inches and at the smallest part 5 by $4\frac{1}{2}$ inches. It weighed 3 cwt. 8 lbs., but as it was thickly coated with rust, and contained oxidised slag in the hollow upper part, also much imprisoned slag, it is probable that the net weight of the metallic part was not more than 3 cwt."* The bloom showed a decided lack of homogeneity, having been made by building up and welding in sections. It contained a good deal of enclosed slag. At points the metal proved to be " really steel, possibly produced by the carburisation of the spongy iron initially produced when the ore was being reduced in a charcoal fire, and probably the result of accident rather than design. The upper central portion of the bloom was little better than a mixture of iron and cinder, similar in character to a spongy ball of puddled iron. The analysis of the interposed cinder proves that the cinder itself is not a refuse slag, but probably oxide produced by the oxidation of

* Stead, *loc. cit.*

almost pure iron, which might be the result of heating a large number of small pieces of the iron preparatory to welding."

Stead gives the average analysis of the bloom as follows :

	Per cent.
Carbon,	0.097
Silicon,	0.046
Sulphur,	0.025
Phosphorus,	0.044
Arsenic,	0.049
Copper,	0.010
Manganese,	0.040
Cinder,	0.380

The bloom was undoubtedly made direct from ore, and Louis suggests that it was obtained from the outcrop of local black-bands. He concludes "that the Romans smelted their little balls of iron with charcoal at or near the outcrop of the local ores, and transported the cakes of spongy iron thus produced into the town of Corstopitum to be worked up." Louis states that he has seen similar procedures in India and mentions that the famous Delhi Pillar was probably made in this way (see p. 143).

Richborough.—The recent excavations at Richborough Castle, near Sandwich, Kent, once the site of an important Roman naval station known as Rutupiae, have revealed many features of interest. The work has been carried out under the ægis of the Society of Antiquaries. Rutupiae is frequently referred to by early Roman writers, and the neighbouring coast was famous for its oysters, which appear to have been held in high esteem at Rome. The first Roman settlement* probably dates from soon after the invasion of Claudius in A.D. 43, and a more extensive occupation followed towards the close of that century.

* See the Official Guide to Richborough Castle, 1924.

It was to be anticipated that careful excavation at this site would yield much of interest. Amongst the finds mentioned are listed several thousand coins, including four gold ones. Other finds include :

Leather Roman shoe, found at the bottom of a well 37 feet deep.

Two small earthenware oil lamps, one in splendid preservation.

Several clay pots, one perfect.

Much beautifully polished pottery, bearing the potter's marks, which will reveal name of maker and the date or place where it was made.

A large quantity of marble with deeply cut letters on some pieces.

Dice carved in stone.

Brooches, bangles, rings, and the head of an iron axe.

In addition to the axe head mentioned a considerable quantity of iron has been unearthed, some of it being certainly of Roman origin, whilst other pieces may possibly be somewhat later. Samples of both have been described in detail.* The genuinely Roman iron was in the form of nails from 10 to 15 centimetres (4 to 6 inches) in length. They were coated with brown rust, more or less contaminated with earthy matter. Beneath this was a layer of magnetic oxide. One of the nails was sawn through, the central portion being filed into cylindrical form and tested for resistance to corrosion, the two ends being reserved for analysis and micrographic examination. The coating of brown, hydrated rust was very thin and appeared to "grow" from the magnetic oxide beneath, as if this latter had, during the lapse of centuries, undergone slow superficial oxidation and hydration to form rust. The magnetic oxide varied in thickness from a thin film to about 1 millimetre, and enclosed an irregular bar of iron roughly 0.7×0.5 square centimetre in cross-section.

* Friend and Thorneycroft, *Journal of the Iron and Steel Institute*, 1925, II., 225.

The analysis is given in the fourth column of the accompanying table, the second and third columns giving the compositions of average mild steels of modern manufacture.

Analysis of Richborough and Folkestone Irons.

1.	2. Modern Mild Steel I.	3. Modern Mild Steel. II.	4. Richboro' Nail I. Roman.	5. Richboro' Nail II. Probably Roman.	6. Folkestone Roman Nail.
Carbon, .	0.080	0.080	0.080	0.070	0.120
Silicon .	0.170	0.068	...*	...*	...*
Manganese,	0.360	0.370	nil	nil	nil
Phosphorus,	0.040	0.007	trace	nil	0.001
Sulphur,	0.025	0.070	0.046	nil	0.034

Micrographic examination showed that the metal was irregular in structure, some portions showing a typical ferrite structure, with only small amounts of pearlite. The more highly carburised portions showed varying structures, of which Fig. 4 is one of the most interesting.

As regards resistance to corrosion, a test was made by exposing a cylindrical piece of the metal to alternate wet and dry in a tank specially constructed for the purpose. As standard an exactly similarly sized piece of modern mild steel, the analysis of which is given in column 3 of the above table. After two months the metals were cleaned and weighed, the loss in weight being taken as a measure of corrosion. The results were as in table on p. 129.

Both specimens were pitted, the Roman iron being slightly the worse of the two. It is very interesting that the total loss in weight of the Roman metal should only approximate to half of that of the modern metal, and

* Not determined, value too uncertain in consequence of slag inclusions.

Corrosion of Roman Iron from Richborough Castle.

Alternate wet and dry (two months).

	Roman Iron.	Mild Steel II.
Original weight, grammes, . . .	15.1230	16.5590
Loss in weight,	0.2430	0.4190
Relative corrosion,	58	100

Fig. 4.—Micro-Section of Roman Iron from Richborough Castle $\times 120$.

this in spite of the good quality and homogeneous character of modern steel. This point is referred to again

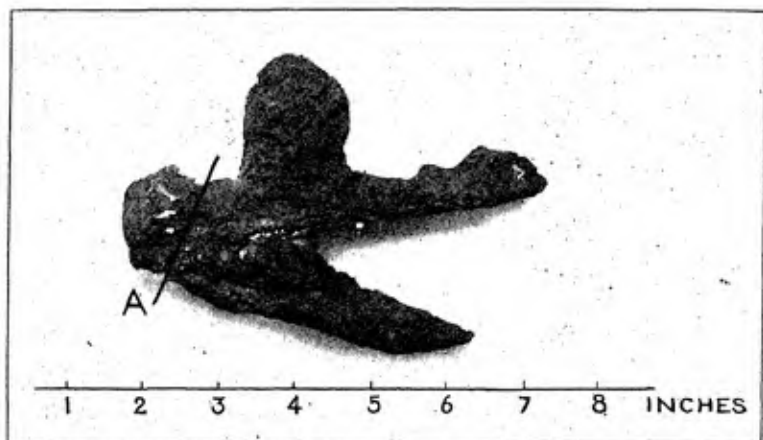


Fig. 7.—Iron from Richborough Castle.

The curious piece of iron shown in Fig. 7 weighed 450 grammes, and when sawn through at A showed (Fig. 8)



Fig. 8.—Cross-Section at A in Fig. 7.

that it consisted of a bundle of bars which had apparently been "welded" together, with thick layers of impurity between. The cementing impurity was surprisingly hard. Analysis showed it to contain 45·47 per cent. of iron and 24·54 per cent. of insoluble material, mainly silica.

Further examination of A showed that the crudely welded bar had been bent round into the **V** shape, several small pieces shaped like a letter **U** being extracted from the mass after the cementing material had been broken away.

Folkestone.—In August 1923, East Cliff, Folkestone, was definitely located as a Roman site, and excavation was undertaken the following April by the Folkestone Corporation, under the direction of Mr. S. E. Winbolt.* Foundations of two separate villas of unequal size were laid bare, and it was evident that most of the windows of the larger one had commanded an uninterrupted view across the Straits to Gessoriacum—the modern Boulogne—which, for nearly two and a half centuries, was the headquarters of the fleet organised by the Romans to protect the Channel. The site under discussion was occupied by the Romans before the end of the first century, namely A.D. 90, and was probably evacuated about the time of the Saxon raids, *circa* A.D. 388. Apparently it is the only seaside Roman villa site on the Kentish coast. It was not expected that rich finds would be made during the excavations, nevertheless many objects of interest were unearthed, the best of which repose in the Folkestone Museum. These include coins, pottery, and objects of bronze and iron.

Amongst the iron objects listed are the following :

* For particulars of the excavations see "Roman Villa Site, East Cliff," by S. E. Winbolt (2nd edition, 1924). Issued by Borough of Folkestone. Also "Roman Folkestone," by S. E. Winbolt (Methuen, 1925).

1. Stylus of iron, 4 inches long, with top end flattened for erasing.
2. Iron key, 5 inches by $2\frac{3}{4}$ inches, with a ring at end of handle, and two wards, one broken.
3. Coulter (or share) of plough, with big iron socket into which wooden beam was fitted.
4. A big iron cramp, 5 inches by $2\frac{1}{2}$ inches.
5. An instrument like a big chisel with tang for handle; length, 8 inches.
6. Two choppers with tangs for handles.
7. A round, tapering instrument, perhaps for boring holes; about 3 inches long, with tang for handle.
8. Curved part of two stirrups.
9. Ring, $1\frac{1}{2}$ inch diameter.

Some of these are shown in Fig. 9, which is reproduced from Mr. Winbolt's "Roman Folkestone," by the courtesy of the author and the publishers.

In addition to these, of course, were many odd pieces of metal, including nails of various shapes and kinds, ranging from 4.5 to 11 centimetres in length and from 0.6 to 2.0 centimetres across. In the main, however, they were somewhat more slender than the corresponding samples from Richborough. One of the best nails was sawn in two, one portion being tested for corrosion, the other examined micrographically and chemically.* All the nails were coated with rust of the usual brownish, earthy character, beneath which was a layer of varying thickness of magnetic oxide. In the case of one nail, the most slender of all, there was no metallic iron. A second nail had a thin core of metallic iron no thicker than a small sewing-needle. Other nails had varying quantities of metallic iron in their cores, though not always continuously throughout their length. If the magnetic oxide was formed by oxidation of the metal whilst hot at the time of manufacture, the nails must have been of very uncertain strength even when freshly made.

* Friend and Thorncycroft, *Journal of the Iron and Steel Institute*, 1925, II., 225.

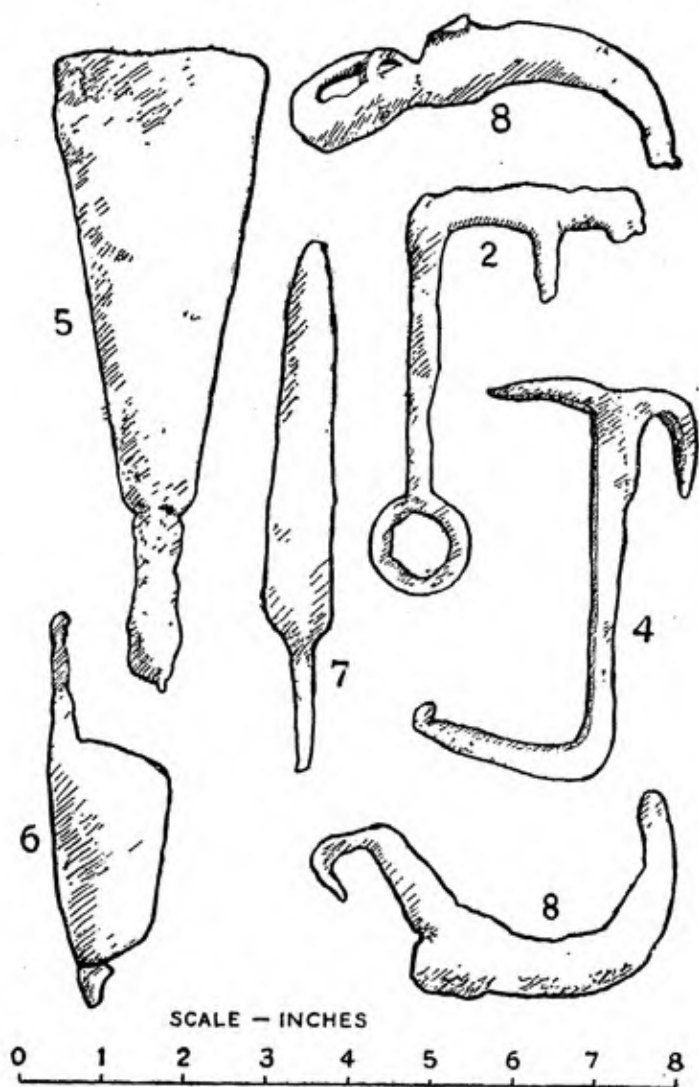


Fig. 9.—From objects to scale, except 7, which is $3\frac{1}{4}$ inches long.

Micrographic examination showed the metal to be very irregular in structure, and of somewhat higher carbon content than the Richborough specimens, as shown by the analysis in column 6 of the table on p. 128. In general the metal resembles that used in the construction of the iron beams of the Black Pagoda at Konarak, India,* but which dates back only to the thirteenth century.

Tests with regard to corrodibility were made in a similar manner to those already described for the Richborough specimens, a piece of Roman iron and modern mild steel of similar size being exposed to alternate wet and dry for three months. The mild steel used had the composition shown in column 2 of the table on p. 128. The Roman iron was again distinctly less corrodible than the modern metal.† It was deeply pitted, and it seemed as though the pits tended to end at the laminations, and not to pass indefinitely through the metal, as frequently occurs in modern homogeneous mild steel. Probably, therefore, it is the irregularly laminated structure that assists in the preservation of these early specimens. The low density of the metal is undoubtedly largely due to the presence of hollows and slag or oxide inclusions.

Uriconium.—The site of the ancient city of Uriconium or Viroconium is situated some five miles south-east of Shrewsbury on the east side of the River Severn, near to the modern town of Wroxeter. It was probably the chief town of the Cornovii who occupied an area including both Wroxeter and Chester. It was no mean city, for the area within the walls amounted to 170 acres, and was thus about one-third larger than Silchester, and 20 acres larger even than Pompeii. Several excavations have been made

* See p. 152.

† The relative rates of corrosion were: mild steel, 100; Roman iron, 70·7.

on the site, the most thorough and scientific are those begun in 1912 and continued at intervals until the present time.* An interesting light is thrown upon the early history of the town by inscriptions on the tombs of two soldiers of the Fourteenth Legion which have been found. This legion saw active service in the invasion of Britain under Aulus Plautius, the general sent by Emperor Claudius, A.D. 43, and took part in the crushing defeat of Boadicea, A.D. 61. The two tombs appear to date back prior to 50 A.D. rather than after that year, from which it may be inferred that the city was inhabited very shortly after the Claudian invasion. Protected as it was by the Severn, and situate on the edge of the hills, it would form an excellent base for operations against the fierce Welsh tribes. When peace had finally been established by Agricola in 78 A.D., the town entered upon an era of great prosperity. What caused its final downfall is unknown. Some believe the town was destroyed by fire and the inhabitants massacred. That was likely enough. Although we know very little of what was taking place in this part of Britain in the second half of the fourth century, it is certain that the country was in a very unsettled state. The dates on coins unearthed from the site cease abruptly about 380 A.D., and it seems probable that Uriconium was destroyed about this time. Further than this it is not yet possible to say.

From amongst the numerous metal finds may be mentioned the following iron objects, which seem of considerable interest :

* See Bushe-Fox, "Reports of the Research Committee of the Society of Antiquaries of London." Excavations on the site of the Roman Town at Wroxeter, Shropshire, First Report, 1912; Second, 1913; Third, 1914. A further report on more recent work is in preparation under the ægis of the Birmingham Archæological Society.

1. A pair of compasses with interlocking hinge as in modern examples. (1912 Report.)
2. Iron key-handles with ornamented bronze heads, an interesting example of the employment of the two metals together. (1912 Report.)
3. Iron netting needle with a prong at each end. (1913 Report.)
4. Several iron caltrops, as they are called. These are four-spiked implements which, when thrown on the ground, always fall in such a manner that one spike points upwards (Fig. 10). These

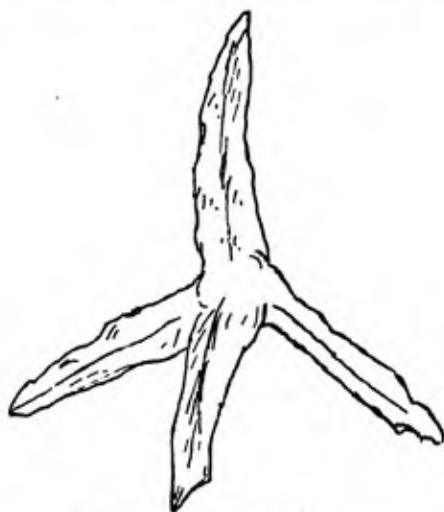


Fig. 10.—An Iron Caltrop from Uriconium.

were used to hinder the advance of the enemy by wounding the feet of horse or man, with the projecting spike. (1913 Report.)

5. An iron finger ring set with a blue paste gem, engraved with a draped figure standing left, with left hand resting on a column and the right grasping an object that cannot be identified. It is thought perhaps, to represent Venus admiring herself in a mirror. A silver ring was also found and, of course, numerous bronze rings, brooches, and other ornaments. (1914 Report.)

In addition to the foregoing mention may here be made of an iron ring, not unlike a serviette ring, probably a ferrule, 4.3 centimetres in diameter and 1.5 centimetres deep. It had been made by bending over on to itself a strip of sheet iron and bronze soldering the ends together with some copper alloy. This appears to be the first duly authenticated example of bronze soldering by the Romans.* At the time of writing the particular composition of the cupriferous alloy has not been determined. Searching through the literature, the present author has not been able to find any other reference to this kind of work. One of the great difficulties of a work of this kind lies in the fact that the antiquary naturally desires to preserve his "finds," and hesitates to allow objects of interest to be examined by any chemical or metallurgical process that may tend to destroy them. With this all must sympathise. But where specimens are not unique, but fairly common, it might be possible to hand some of these over to tried investigators in order that science might benefit by a further examination, even at the risk of spoiling for exhibition purposes these duplicated specimens.

Horse-shoes have long been regarded as contributory to good luck. The horse-shoe nailed to the wooden mast of Nelson's Flagship, and preserved in the Whitehall Museum, no doubt enabled the British to win a decisive victory at Trafalgar on October 21st, 1805, but was not sufficiently powerful to protect Nelson himself, who was mortally wounded in the engagement. Perhaps that was due to the fact that the shoe was nailed Ω and not \mathfrak{U} , so that Nelson's luck ran out of it!

At Oakham Castle, Rutland, is an old board bearing several horse-shoes, and is probably a relic of the old Gate upon which, it is recorded, horse-shoes were formerly

* Friend, *Nature*, 1925, 116, 749.

nailed. Oakham belonged to the Ferrers family. The original Ferrers came over with the Conqueror in 1066, being indeed Master of Horse and bearing arms semée of horse-shoes, as evidenced from the famous Roll of Battle Abbey. Ferrers' descendants bore the same arms and possessed the curious right of demanding* "that every Peer on his first passing through the town should leave a shoe from off his horse, or, as is always done now, a piece of money to have one made, to be hung in the castle." The custom appears to have been "to stop the horse or carriage until a sum of money was given. If the person so stopped did not comply, a shoe was taken off his horse. One can quite imagine the stranger being only too glad to pay the fine and be permitted to continue his journey."

Possibly this was one of the means adopted by the family to replenish their purse, and was simply a variety of the toll exacted in various ways in other places from the traveller.

The name Ferrers is probably derived from the place Ferrière, in France, and may or may not be connected with the Latin *Ferrarius*, smith.

In this connection reference may be made to the horse-shoe in the middle of the road at Horse-Shoe Corner in Lancaster. The shoe is said to have been cast from John of Gaunt's horse on one occasion as he rode through the city, *circa* 1380. It is a pretty tradition which fortunately is not destroyed by the repeated replacement of the shoe by new modern ones as the older specimens wear out under the stress of modern traffic. What matter if historians quibble amongst themselves as to whether or not John of Gaunt ever visited the city. There is the shoe! What more do we want?

In 1235 King Henry III. granted a property in the

* See "Oakham Castle," by Pearl Finch (Oakham, 1903).

Parish of St. Clement Danes, the present location of which is unknown, to Walter le Brun for repairing—so tradition says—the armour of a Knight Templar wounded in a tournament. The rental was fixed at 6 horse-shoes and 61 nails. This “service” is still rendered to the Crown on behalf of the Corporation of London, the original horse-shoes being still used in the ceremony.

CHAPTER XI.

IRON IN INDIA.

THERE can be no doubt that iron was known in India at a very early date. The metal was certainly worked some 2000 B.C., and from certain passages in the "Black Yajurveda" it has been concluded* that some form of iron cannon or engine of war was in use between 2000 and 1000 B.C. Romesh Chander Dutt records the use of gold, silver, tin, lead, and iron as being well known 1400 to 1000 B.C.† But early traditions in Eastern lands must always be scrutinised most carefully, for the imagination of Easterners is apt to run riot. It is noteworthy, however, that the Indian contingent in the army of Xerxes is stated by Herodotus to have carried bows of cane and arrows also of cane but pointed with iron.‡ Evidently, therefore, iron was in use for military purposes *circa* 500 B.C., and from that time onwards its use became increasingly more frequent. Probably the most remarkable instance of its employment appears in a medical work, in which nearly 100 surgical instruments are described as used for delicate operations. From certain burial sites in the district of Tinnevely, iron swords and daggers have been unearthed. They are prehistoric and of uncertain

* Neogi, *Journal of the Royal Society of Arts*, 1914, vol. lxiii., p. 43.

† Lester, Presidential Address to the Staffordshire Iron and Steel Institute, September 30, 1911.

‡ Herodotus, Book vii., Chapter lxv. Xerxes was King of Babylon B.C. 485 to 455.

date. Specimens of third century iron have been recovered from Buddha Gaya.

Delhi.—Perhaps the most famous specimen of ancient iron in India is the pillar at Delhi (see Frontispiece), to which, owing to a regrettable series of errors, the date of 912 B.C. has repeatedly been assigned. In reality it only dates back to about A.D. 300. It is 23 feet 8 inches in height, 22 feet being vertically above ground and 20 inches below. Its upper diameter is $12\frac{1}{2}$ inches; its lower $16\frac{1}{2}$ inches; whilst its total weight is approximately 6 tons.* According to Miss Gordon Cumming,† “it is wrought like our finest metal, and shows no symptoms of rust, though it has stood here for many centuries. It bears an inscription in Sanscrit, describing it as the ‘triumphal pillar of Rajah Dhava, A.D. 310, who wrote his immortal fame with his sword.’ This, however, is the only record extant of his deeds. There are several other inscriptions on the pillar, but of more modern date.

“The Brahmin tradition is, that this pillar was erected in the sixth century, after the stars had pointed out the auspicious moment. It went so deep that it pierced the head of the serpent god Schesnag, who supports the earth. The priests told the Rajah that thus his kingdom should endure for ever. But, like a child gardening, he could not be satisfied till he dug it up again, just to see it if were so, and sure enough the end was covered with blood. Then the priests told him that his dynasty would soon pass away. He planted the pillar again, but the serpent eluded

* Hadfield, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 156; Cunningham, “Archæological Survey of India” (Four Reports made during 1862-1865), Simla, 1871; St. John Vincent Day, *Proceedings of the Philosophical Society of Glasgow*, 1872, vol. viii., No. 2, p. 235; Vincent A. Smith, *Journal of the Royal Asiatic Society*, 1897, p. 11; 1898, p. 143.

† Miss Gordon Cumming, “In the Himalayas and on the Indian Plains.”

his touch, and the pillar was thenceforth unsteady. So the priests called the name of the place Dhilli, that is 'unstable,' and prophesied all manner of evil concerning the Rajah, who shortly afterwards was killed, and his kingdom seized by the Mahommedans, and since then no Hindoo has ever reigned in Delhi.

"Nevertheless, the pillar is now as firm as a rock,* and has even resisted the cannon of Nadir Shah, who purposely fired against it. The marks of the cannon balls are clear enough. The Hindoos believe that so long as this column stands, the kingdom has not finally passed from them."

India is a land of legend. A Hindoo judge has informed the writer that there is probably no connection whatever between the name *Delhi*, given to the city of that name, and the word *dhili*, loose or unstable. The word Delhi more probably means "Heart's Delight."

"This tradition is related in a more poetical form by Kharg Rai," says Cunningham, "who wrote in the reign of Shahjahan. According to him, the Tomar Prince was provided by the sage Vyās with a golden nail, or spike, 25 fingers in length, which he was told to drive into the ground. At a lucky moment, on the 13th day of the waning moon of Vaisākh, in the Samvat year 792, or A.D. 736, when the moon was in the mansion of Abhijit, the spike was driven into the ground by the Raja. Then said Vyās to the king :

Ne'er will thy kingdom be besped,
The spike hath pierced Vasuki's head.

"Vyās was no sooner departed than the incredulous Raja boldly declared his disbelief in the sage's announcement, when immediately—

* But it is not now on its original site. Perhaps that accounts for its stability!

He saw the spike thrown on the ground,
Blood-dropping from the serpent's wound.

"The sage was recalled by the horrified king, who was directed to drive the stake into the ground a second time. Again he struck, but the spike penetrated only 19 fingers, and remained loose in the ground. Once more then the sage addressed the Raja prophetically, 'Like the spike (*killi*) which you have driven, your dynasty will be unstable (*dilli*), and after "nineteen" generations it will be supplanted by the Chocans, and they by the Turkans.'"

Cunningham suggests that the long reign of the Tomar dynasty had led to a belief in its permanence which would naturally be compared with the pillar fixed in the ground. A parallel case occurs in Rome, where an old saying, immortalised in verse by Byron, points to a like suggestion :

While stands the Coliseum, Rome shall stand ;
When falls the Coliseum, Rome shall fall.

The pillar is a magnificent tribute to the skill of the early metallurgists of 1,600 years ago. It is not a casting but "a huge forging in native Indian or some other Asiatic-made wrought iron."* It was built up by welding discs of iron, and it is stated † that the marks of welding were a few years ago—and possibly are to-day—plainly to be seen.

The pillar is not now on its original site, from which it was moved in A.D. 1052 and placed in its present position as an adjunct to a group of temples, from the materials of

* Mallet, quoted by Day, *Proceedings of the Philosophical Society, Glasgow*, December 4, 1872.

† See discussion by Turner, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 184.

which the Mahommedans afterwards constructed the great mosque.*

A curious feature of the pillar is its remarkable freedom from rust. Hadfield was able to obtain specimens and to submit them to analysis with the following result : †

	Per cent.
Carbon,	0.080
Silicon,	0.046
Sulphur,	0.006
Phosphorus,	0.114
Manganese,	nil
Nitrogen,	0.032
<hr/>	
Total of elements other than iron, including copper.	0.034
Iron,	99.720
<hr/>	
Total,	100.032
<hr/>	

Density, 7.81.

Brinell hardness, No. 188

This is probably the first analysis ever made of the pillar. "It will be noticed that the material is an excellent type of wrought iron, the sulphur being particularly low (0.006 per cent.), indicating that the fuel used in its manufacture and treatment must have been very pure (probably charcoal). The phosphorus is 0.114 per cent. There is no manganese present. . . . The iron was ascertained by actual analysis, and not "by difference," ‡

"The high phosphorus and low carbon, sulphur, and manganese contents all tend towards reduction of corrosion, but do not suffice to explain the general immunity of the pillar from corrosion." § This suggests

* V. A. Smith, "Early History of India" (Clarendon Press, 1924), p. 401.

† Private communication from Sir Robert Hadfield.

‡ Hadfield, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 171 (Insertion).

§ Friend, *Transactions of the Concrete Institute*, 1917-18, vol. ix.

that the resistance to corrosion is due to the surface condition of the metal, which in other similar cases is usually known to be highly polished, and looks as if coated with a fine adherent layer of slag.* Possibly the ancient custom of anointing the pillar with butter at certain religious festivals may have something to do with this.

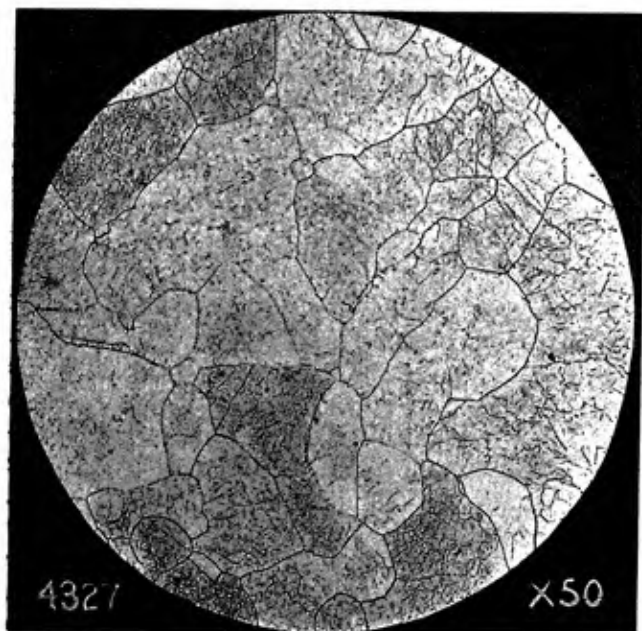


Fig. 11.—Iron from the Delhi Pillar. $\times 50$.
(Photo by Sir Robert Hadfield.)

The photomicrograph of the iron shown in Fig. 11 and reproduced by the courtesy of Sir Robert Hadfield is interesting.

* Desch, *Journal of the West of Scotland Iron and Steel Institute*, 1913-14.

The structure consists of large grains of ferrite with a very small portion of cementite, sometimes located in the grain junctions and occasionally in the ground mass.

A smaller grain structure independent of the larger one is more or less faintly traceable. There are also a large number of small lines, which at higher magnification are shown to have a regular formation and appear related to the smaller grain structure, and may be due to secular effects—that is, ageing.

On reheating a portion of the specimen to 900° C., the whole of this fragmentary grain structure is made to disappear leaving only large clear etching ferrite grains.

The specimen is remarkably free from slag and other inclusions, and is evidently a very pure iron.

Discussing the general freedom of Indian iron from rust, Wallace,* writing from Bombay, states; "I have seen native-made iron forged on a stone anvil, and have observed that it does not rust like English iron when exposed to the weather. The ironwork of the car on which the gods of the Kulu Valley take the air has a fine brown patina and no rust flakes. It is all charcoal iron."

"Can it be," asks Carulla,† "that the stone anvil mentioned by Mr. Wallace siliconides the skin of the Indian iron?" Such an explanation sounds very plausible.

The Dhār Pillar.—Another iron pillar was erected at Mandu, some twenty-two miles from Dhār, or Dhārā, the ancient capital of Mālava, thirty-three miles west of

* John Wallace, *Journal of the Iron and Steel Institute*, 1908, No. I. p. 84.

† Carulla, *Journal of the Iron and Steel Institute*, 1908, No. I., p. 85.

Indor.* It was probably entire in A.D. 1304. "It was thrown down by the Mahommedans and broken into two pieces. After 100 years the larger piece was brought to Dhār, about 1405, when it was erected, but knocked down again and broken into two pieces about 1531."† The pillar is thus now in three portions scattered in the town. "The longest portion is 24 feet 3 inches, and is square in section throughout; the second is 11 feet 7 inches, of which 8 feet 6 inches is square and 3 feet 1 inch octagonal; and the third piece, 7 feet 6 inches in length, is of octagonal section except for a circular section at one end, 8 inches deep. The octagonal section is very irregular in form. The total length is 43 feet 4 inches, and the average section is $104\frac{1}{4}$ inches square. One end of the longest piece, which was originally the base, is slightly bulbous, being 11 to $11\frac{1}{4}$ inches wide at 2 feet from the end, while the rest measures $10\frac{1}{4}$ to $10\frac{1}{2}$ inches. Although the length is given as 43 feet 4 inches, it is quite possible from consideration of the proportions and sizes of the octagonal and square portions, that there is a fourth and missing piece, which would bring the total length up to 50 feet."

If these figures are correct, this gigantic column was more than double the height of the Delhi pillar. As Vincent A. Smith says,‡ we marvel at the skill shown by the ancient artificers in forging the great mass of the Delhi pillar, and must give a still greater measure of admiration to the forgotten craftsmen who dealt so

* See Vincent A. Smith, *Journal of the Royal Asiatic Society*, 1898, p. 143; Graves, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 188; Cousens, *Annual Report of the Archaeological Survey of India*, 1902-3. (Issued in 1904 from the Government Press, Calcutta.) † Graves, *loc. cit.*

‡ Vincent A. Smith, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 158.

successfully in producing the still more ponderous iron mass of the Dhār monument which, like the pillar at Delhi, is of the Gupta period, or about the year 321 of the Christian era. These are the largest masses of ancient iron known to the world, and it is only within comparatively recent years that moderns have learned to deal with masses of iron approaching these in size.

A fragment of the Dhār Pillar has been analysed by Sir Robert Hadfield,* with the following result :

	Per Cent.
Carbon,	0.02
Phosphorus,	0.28
Iron,	99.60

The question has been raised as to whence India derived her knowledge of iron. Babylon is suggested,† and it is well established that from very early times iron has been known in what is now Mesopotamia. Others suggest that the Hindoos discovered iron themselves.‡ This is very reasonable. There is, of course, no need to attempt to trace back the discovery of iron to one source. Just as at the present time discoveries are not infrequently made simultaneously in different parts of the world, so it is reasonable to suppose that in early days, when means of communication were slow and primitive, different nations or tribes may have simultaneously unravelled certain of nature's secrets quite independently.

Konarak.—A passing reference to the iron beams from the Black Pagoda at Konarak in the Madras Presidency will suffice, for, although numbers of these heavy beams still lie scattered round the building, in all probability

* Private communication from Sir Robert Hadfield.

† In the case of Northern India. Vincent A. Smith, *loc. cit.*, p. 184.

‡ Notably by J. M. Heath in two papers on Indian steel before the Royal Asiatic Society, 1837, vol. iv. ; 1839, vol. v.

they only date back to the thirteenth century.* A detailed description is given by Graves,† who states that the temple lies some twenty miles from Puri, which is some 12 hours or 311 miles from Calcutta. "Originally the beams were used as supports under the lintels of the doorways and to expedite the corbelling-in of the roof. . . . The Konarak temple has been closed up and filled in with masonry and sand to prevent further falls, so it is not possible to say exactly where the beams were originally placed and whether there are any left *in situ*. Nearly all the beams have been broken by the fall. Some are very heavily rusted, but many are scarcely affected or have a very thin and closely adhering coating. One beam, which is now lying on the portico, has evidently been partially exposed for a long period to the sandy winds, for it is worn down at least an inch in depth, enabling the defective structure to be seen.

"This particular beam and the fractured ends show very clearly that the method of manufacture was by welding up small blooms, generally about 3 or 4 lbs. in weight. The blooms are commonly 2 by 1 inch in section, but occasionally 2 by 2 inches or 1 by 1 inch, and a common length is about 6 inches. . . . Many of the broken ends show the existence of irregular and sometimes uniform cavities. It is possible to thrust a stick down some of them to a depth of 7 or 8 feet, and the sand-blasted specimen shows a cavity nearly the whole length of the beam. From these hollows bits of cinder can be raked out."

A specimen of this Konarak iron has been submitted

* Vincent A. Smith, *loc. cit.*, p. 184; Ferguson, "Illustrations of Ancient Architecture in Hindostan" (London, 1848).

† Graves, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 187.

to micrographical and chemical examination.* In preparing a section for the microscope some difficulty was encountered in obtaining a satisfactory surface owing



Fig. 12.—Microsection of Konarak Iron. $\times 50$.

largely to the slag inclusions in the cracks. In the centre of the specimen were a number of holes varying in size

* Friend and Thorneycroft, *Journal of the Iron and Steel Institute*, 1924, No. II., 313.

and depth, from which "cracks" radiated. The photograph (Fig. 12), taken at a magnification of 50 diameters, shows a portion of the specimen near one of the cracks. The crack itself is seen as a black band, in contact with which is a light band of ferrite, the grain boundaries being faintly discernible; while this, in turn, passes into a mixture of pearlite and ferrite.

Portions of the specimen more distant from the cracks showed a fairly uniform structure, typical of mild steel containing rather less than 0.15 per cent. carbon; whilst portions bordering on the holes and cracks were free from pearlite. These observations lend support to the statement by Graves that the method of manufacture consisted in welding up small blooms, and it would appear that decarburisation took place during the welding.

The metal was found to be very soft, the Brinell hardness number (using a load of 500 kilogrammes) having a mean value of 72—a value less than half of that (namely, 188) found by Sir Robert Hadfield for the Delhi metal.

A test was made with the Shore scleroscope in order to determine any variations in hardness. Using the magnifier hammer the hardness number varied from 31 to 28 in different parts of the specimen.

Owing to the irregularity of the metal, to which attention has already been directed, it was a little difficult to choose a thoroughly representative portion for analysis. The piece ultimately chosen was as free as possible from attached slag, and its composition is given in the accompanying table, together with that of a sample of modern mild steel; analyses of specimens from the famous Delhi and Dhār pillars and from Sigiriya in Ceylon, as given by Sir Robert Hadfield,* are also quoted for the sake of comparison. The low phosphorus content

* See p. 156.

Analyses of Indian and Other Irons.

	Konarak Iron. c. A.D. 1250.	Modern Mild Steel.	Delhi Pillar. c. A.D. 300.	Dhār Pillar. c. A.D. 320.	Ceylonese (Sigiriya). c. A.D. 450.
Carbon, .	0.110	0.080	0.080	0.02	traces
Silicon, .	0.100	0.170	0.046	...	0.26
Sulphur, .	0.024	0.025	0.006	...	0.022
Phosphorus,	0.015	0.040	0.114	0.28	0.34
Manganese,	trace	0.36	nil	...	traces
Copper, .	...	...	...	...	0.012
Hardness (Brinell).	72	...	188	...	...

is noteworthy, in view of the high percentage present in the other Indian and Ceylonese specimens. The silicon is higher than in the Delhi pillar, but this may well be due to slag or other siliceous inclusion. The carbon is a little high. On the whole, however, the composition indicates that the source of the metal was very pure. The sulphur content resembles that of the Ceylonese metal.

A few tests were made with the object of determining the resistance of the metal to corrosion. To this end the metal was cut into a small rectangular block and exposed, along with a similar block of modern mild steel, to the corrosive influence of alternate wet and dry (tap water) for one year. The specimens were then removed, cleaned, and weighed, the loss in weight being taken as a measure of corrosion.

The specimens were next exposed for one year to the action of artificial sea-water, made by dissolving the requisite quantity of Cheshire rock-salt in tap water.

The results of the two sets of tests were as follows :

	Alternate Wet and Dry.	Sea Water.
Modern mild steel,	100	100
Konarak iron,	89.3	75.3

It is interesting to note that in both sets of experiments the ancient metal proved appreciably more resistant to corrosion than the modern mild steel.* It is certainly very curious that, in most cases where ancient irons have been tested, their resistance towards corrosion has been very marked, the life of modern steel, despite its well-made and homogeneous structure proving much shorter. Is this to be regarded as another proof of the adage that the good die young?

* See also pp. 129, 136.

CHAPTER XII.

IRON IN CEYLON.

It is not a far cry from India to Ceylon. "In 543 B.C., Wijiyo and his Sinhalese followers landed in Ceylon, possibly near the modern Puttalam on the west coast. He is said to have been the discarded son of one of the petty princes in the valley of the Ganges, while the native chronicles explain the name of his race by tracing his paternity to a lion—'Sinha.'"^{*} During the excavation of some of the ancient buried cities of Ceylon, which date back to the above-mentioned period, and which have had a more or less continuous human history until as late as the sixteenth century, some specimens of ancient iron have been discovered. These number about 250 pieces, and are housed in the Museum at Colombo. Three specimens were submitted to Sir Robert Hadfield for investigation, the results being published[†] in 1912.

The details are as follow :

- (1) *Chisel from Sigiriya, of the fifth century A.D.*

Length,	.	.	.	.	.	10 inches.
Density,	.	.	.	.	.	7.69

^{*} S. M. Burrows, "The Buried Cities of Ceylon," 1905.

[†] Hadfield, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 134.

<i>Analysis.</i>				
Carbon,	.	.	.	traces
Silicon,	.	.	.	0.12 per cent.
Sulphur,	.	.	.	0.003 "
Phosphorus,	.	.	.	0.28 "
Copper,*	.	.	.	0.090 "
Manganese,	.	.	.	nil
Iron (estimated direct, not "by difference"),	.	.	.	99.3 "
Total,	.	.	.	99.793

The difference represents slag and oxide.

Micrographic examination led to the conclusion that the chisel had been quenched, the structure being martensitic in parts. Troostite was also detected.

(2) *Nail* (probably also from Sigiriya).

Length,	.	.	.	13½ inches
Density,	.	.	.	7.69

<i>Analysis.</i>				
Carbon,	.	.	.	traces
Silicon,	.	.	.	0.11 per cent.
Sulphur,	.	.	.	nil
Phosphorus,	.	.	.	0.32 "
Copper,	.	.	.	0.119 "
Manganese,	.	.	.	nil

Micrographic examination revealed slip-bands and showed that the metal had undergone severe hammering. The carbon in the carburised areas existed as granular pearlite.

(3) *Native Bill-hook or Ketta.*

Length,	.	.	.	12½ inches.
Density,	.	.	.	7.50

For Analysis, see p. 154.

The specimen was very corroded, being covered with thick, brown rust. Micrographic examination showed

* Hadfield, *loc. cit.*, p. 179.

that it contained a large amount of slag and represents what would now be regarded as a somewhat low grade wrought iron.

The analyses are particularly interesting, because it is comparatively seldom that metallurgists have been able to examine authentic specimens of ancient irons. The carbon is low throughout whilst the phosphorus is high, this latter fact probably serving to account for the high tensile strength of the specimens, which was found to be somewhat higher than for wrought iron. The sulphur is extremely low, showing that a very pure fuel, probably charcoal, had been employed in the production of the metal. The manganese is low, and the copper varies. The presence of troostite in the chisel raises the interesting question as to whether or not the martensite had actually been transformed into troostite by spontaneous annealing during the 1,500 years that the specimen had existed.* Apropos of this mention might here be made of the ancient Celtic implements obtained during excavations on the site of Steinsburg at Römhild in Thüringen. One weapon or tool, upon micrographic examination,† disclosed the presence of ferrite, pearlite, and slag. The point had been hardened and was encased with martensite to a depth of 1 millimetre. Further inwards the structure consisted of martensite and osmondite. The weapon is believed to be some 2,000 years old, and whilst it is of interest as showing that the practice of hardening steel was known in Thüringen before the Germans settled there, it also shows, as Hanemann points out, that martensite is very stable in finite time at ordinary temperatures.

* Le Chatelier, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 180.

† Hanemann, *International Journal of Metallography*, 1913, vol. iv., p. 248.

CHAPTER XIII.

IRON IN EGYPT.

IRON has been known in Egypt for many thousand years. The dynastic Egyptians were certainly familiar with the metal, but it was not unknown even to the predynastic race. The oxidised remains of iron beads have been discovered in a tomb in a predynastic Egyptian cemetery at El Gerzeh, some forty miles south of Cairo,* during excavations under the ægis of the British School of Archæology in Egypt. The string of beads round the neck of the skeleton in the tomb held, in its original order, 3 gold beads, 1 iron, 1 gold, 2 iron, 2 carnelian, 1 gold, 1 iron, 3 agate, 1 gold, 1 carnelian, 1 gold, 1 carnelian, 3 gold. The iron beads were examined by Gowland, who reported that "they consist of hydrated ferric oxide, *i.e.*, iron rust, none of the original iron having escaped oxidation. On analysis one gave the following results :

Ferric oxide,	78.7 per cent.
Combined water with trace of CO ₂ and earthy matter,	21.3 „
	<hr/> 100.0 „

"They do not consist of iron ore, but of hydrated ferric oxide, which is the result of the rusting of the wrought iron of which they were originally made."

Similar beads have also been found in other tombs, and it would thus appear established that iron was known to,

* Wainwright, *Revue Archæologique*, 1912, No. I., 255.

and prized by, the predynastic Egyptians possibly some 4000 B.C.* It is difficult, however, to arrive at even approximate dates for these early periods as Budge† argues, "no certain date can be given for the reign of the first King of all Egypt, and most of the Early Egyptian dates may be wrong by as much as three centuries. The dates of the kings of the XVIIIth Dynasty (about 1600-1360 B.C.) have practically been fixed by the cuneiform inscriptions, but strictly accurate dating cannot begin until about 700 B.C." The dates, proposed by Brugsch, Hall and Meyer respectively, for the more important Dynasties mentioned in this section are as follows :

Dynasty.	Brugsch.‡	Hall.§	Meyer.‡
I.	4400 B.C.	3500 B.C.	3315 B.C.
III.	3966 B.C.	3200 B.C.	2895 B.C.
VI.	3350 B.C.	2825 B.C.	2540 B.C.
XII.	2466 B.C.	2200 B.C.	2000 B.C.
XVIII.	1700 B.C.	1600 B.C.	1580 B.C.
XIX.	1350 B.C.	1350 B.C.	1320 B.C.

The problem as to the source of the Pre-dynastic iron beads mentioned above is not easy to solve. Hæmatite was known to the Pre-dynastic Egyptians and may have been reduced, even if only by accident, in their fires. The possibility of their having obtained it by trade from others, such as the negroes, who might have discovered the art, appears equally remote, || for in predynastic and

* Petrie (*Journal of the Iron and Steel Institute*, 1912, No. I., 182) suggests 6000-7000 B.C.

† Budge, "Egypt" (Home University Library, 1925), p. 54.

‡ Given by Budge, *opus cit.*, p. 54.

§ Hall, "The Cambridge Ancient History," 1923, vol. I., p. 656.

|| See Petrie, Wainwright and Mackay, "Labyrinth, Gerzeh, and Maz-chunch" (Quaritch, 1912), pp. 15 *et seq.*

early dynastic times the inhabitants of the Upper Nile Valley, as exemplified by the Nubians, were likewise in their chalcolithic stage of civilisation. Their weapons consisted of flint arrows, stone axes, and the like. Even as late as the eighteenth dynasty (*circa* 1600 to 1360 B.C.) the Nubians and negroes never brought iron to Egypt as tribute, though gold, electrum, precious stones, ebony, ivory, bows, arrows, etc., are listed.* Nevertheless the Nubians were certainly familiar with the metal at this time. It would almost appear, therefore, that the iron had been found native and, owing to its scarcity, was sufficiently highly prized to rank with gold and carnelian as a precious "stone."

In later times the art of working iron appears to have entered Egypt from Asia and to have passed thence to Africa.†

The most ancient piece of dynastic iron yet discovered is that found during blasting operations within the Great Pyramid of Gizeh in 1837. The pyramid was erected in honour of Khufu in the Fourth Dynasty, *circa* 3000 B.C., and the metal cannot be later than this unless, as Petrie points out, it was left there by some later mutilators of the building, which is not impossible.

It was examined by Flight, who concluded that it was not of meteoric origin. Gowland,‡ on the other hand, decided against its being a natural terrestrial product, and suggested that it was "not altogether impossible that it came from the Sinaitic peninsular, and was obtained

* King and Hall, "Egypt and Western Asia in the Light of Recent Discoveries" (S.P.C.K., 1907), pp. 112-116; Hall, *Man*, 1903, vol. iii. p. 147.

† Wainwright, *Bulletin Société Sultanieh de Géographie, Cairo*, 1919, ix., p. 183 *et seq.*

‡ Gowland, "Huxley Memorial Lecture for 1912," Royal Anthropological Institute of Great Britain and Ireland, p. 284.

there by the accidental treatment by the copper smelters of the rich iron ore which crops out near the veins of copper ore."

The Great Pyramid was built of granite blocks from the Upper Nile and lined with Arabian nummulitic limestone. It has frequently been urged that the skill with which these stones have been shaped points to the use of iron tools, as no other material would be sufficiently hard and serviceable. Herodotus* evidently believed this too; at any rate he seems to have taken it for granted, for after describing the pyramid he exclaimed "What a vast sum must have been spent on the iron tools used in the work!" The argument, however, loses force when it is recalled that the early inhabitants of Mexico and of Peru, who were entirely ignorant of iron, were able to cut, shape, and even carve granite and porphyry with the aid of bronze implements and siliceous powder (see p. 202).

Again, the modern Egyptian in plying his trade of forging antiquities shows that hard rocks can be chiselled with soft metals provided due perseverance and patience are exercised. Lawrence Balls,† writing in 1915, states that "there is a workman at Luxor‡ who makes statues out of hard diorite with *chisels of soft iron*. He sits with dozens of chisels round him, and small boys continually sharpening them, since they become blunted after a few blows. Thus he produces work which in one case has actually been shown for a while in the Cairo Museum itself as the genuine article; he was challenged to copy a statue for a bet with an expert, and the bet was won; the statue was put away in a corner and forgotten,

* Herodotus, *opus cit.*, Book II., chap. 125.

† Balls, "Egypt of the Egyptians" (Pitman, 1915), p. 96. The italics are those of the present Author.

‡ The modern city on the site of ancient Thebes.

ultimately finding its way into the Museum before its history was remembered."

Finally, Petrie, who examined most thoroughly the Gizeh Pyramids, in 1880-1881 gave good reasons for believing that the blocks of stone had been sawn through with large bronze saws, more than 9 feet in length, and bearing jewelled cutting edges.*

Whatever uncertainty there may be about the iron found at Gizeh, "an absolutely dated case is that of the mass of rust, apparently from a wedge of iron, found stuck together with copper adzes of the Sixth Dynasty type, at the level of floors of that age in the early temple of Abydos," † *circa* 2800 B.C. It was found by Petrie himself wrapped up in a fabric, together with a mirror. A few other finds of iron have been made, as shown in the accompanying list, but the metal did not come into general use before 1300 to 1200 B.C. ‡ The period, therefore, ranging from the earliest use of the metal down to this later date is aptly termed by Petrie the *Sporadic Iron Age*.

The Sporadic Iron Age of Egypt. §

- | | |
|-------------------------|---|
| <i>Circa</i> 4000 B.C., | Predynastic iron beads at El Gerzeh. |
| 3100 B.C., | Iron tool from the Great Pyramid of Khufu at Gizeh.
Fourth Dynasty. |
| 3000 B.C., | Fragments of iron picks from the Black Pyramid at
Abusir. Fifth Dynasty. |
| 2800 B.C., | Mass of iron rust from Abydos. Sixth Dynasty. |

* Baikie, "A Century of Excavation in the Land of the Pharaohs," R.T.S., p. 68.

† Petrie, "Ancient Egypt," 1915, Part I. p. 20.

‡ Petrie gives the later date. Hall (*Man*, 1903, vol. iii. No. 86) gives the earlier.

§ Compiled from Wainwright's List, p. 19. "Labyrinth, Gerzeh, etc."

|| Found by Maspers in 1882.

- 2200 B.C., . Iron spear head. Twelfth Dynasty.
 1350 B.C., . An iron finger ring. Iron sickle from beneath a sphinx
 of Horemheb near Karnak. Eighteenth Dynasty.
 1200 B.C., . Iron halbert, probably of Rameses III. Three knives of
 Ramesside date or later. A needle from Nubia. All
 about Twentieth Dynasty.

At the time of the accession of Rameses II., *circa* 1300 B.C., the enemies of the Egyptians were beginning to use iron weapons for military purposes, and the difficulty the Egyptians experienced in dealing with the Hittites is attributed, in part at any rate, to the latter's new and more efficient iron weapons.* Indeed, Rameses actually made application to a Hittite king for a supply of iron. Whether or not this was ultimately forthcoming is not known, but a mutilated letter, perhaps addressed to Rameses II. personally, has been found, in which the Hittite king promises to send very shortly a supply of iron, and, as an earnest of what is to follow, states that he is sending, with the letter, an iron dagger.

Towards the close of the 13th century B.C., iron was much more plentiful in Egypt. The armies of Rameses III. appear to have been equipped with iron weapons, for these are painted blue on the monuments.

An interesting sidelight is thrown upon the conditions prevailing in the time of Rameses II. by the Egyptian Papyrus known to the Egyptologist as the Papyrus Anastasi I., or, more popularly, as "The travels of a Mohar." It is a collection of letters written by a professor of literature at the Court of Rameses II., giving a satirical account of the journeyings of a royal messenger. It appears that at Jaffa his arms were stolen from his side and the armour stripped from his unguarded chariot, as he slept in a garden. In modern newspaper parlance this

* "The Cambridge Ancient History," 1924, vol. ii., pp. 267, 272, 524.

would be described as "an impudent theft," and it is noteworthy that the Mohar's prestige as an envoy of the great Rameses was not sufficient to protect him from such indignity. The letters proceed, "Thou comest into Joppa; thou findest the garden in full bloom in its time. Thou penetratest in order to eat. Thou findest that the maid who keeps the garden is fair. She does whatever thou wantest of her. Thou art recognised, thou art brought to trial, and owest thy preservation to being a Mohar. Thy girdle of the finest stuff thou payest as the price of a worthless rag. Thou sleepest every evening with a rug of fur over thee. Thou sleepest deep sleep, for thou art weary. A thief steals thy sword and thy bow from thy side; thy quiver and thy armour are cut off in the darkness, thy pair of horses run away. . . . Thy chariot is broken to pieces. . . . The iron-workers enter into the smithy; they rummage in the workshops of the carpenters; the handicraftsmen and saddlers are at hand; they do whatever thou requirest. They put together thy chariot; they put aside the parts of it that are made useless; thy spokes are fashioned quite new; thy wheels are put on; they put the straps on the axles and on the hinder part; they splice thy yoke, they put on the box of thy chariot; the workmen in iron forge the (?); they put the ring that is wanting on thy whip, they replace the lashes upon it."*

A truly human document!

It appears that even at this early date workmen could be found in Jaffa, skilful in repairing chariots and familiar with the art of forging iron.

It is, indeed, very remarkable that iron should not have been in general use at a much earlier date. It has been

*Tolkowski, "The Gateway of Palestine" (Routledge, 1924), p. 21, from Sayce, "Patriarchal Palestine," 1895, pp. 212-224.

suggested that iron was much better known than we imagine, but that it has oxidised away, leaving little or no trace of its presence. But, as has already been pointed out,* the supposition often put forward that iron might entirely disappear in course of time, is a mere fallacy. When buried in earth iron usually corrodes exceedingly slowly. When it has at last been turned to rust, it has become a material which can hardly ever disappear, for oxide of iron is practically insoluble when buried, and its strong colour and staining power make it very obvious.

If this is accepted it follows that the relative proportions of ferrous to non-ferrous implements that have been found will give a fair idea of the proportions in which they were made and used, and, as this is so small, Petrie concludes that the sources of iron in the sporadic age were either the native metal or else casual production by accident.

The earliest general group of iron tools in Egypt was found at Thebes. They belong to the time of the Assyrian invasion by Ashur-banipal, 666 B.C. When magnetised they mostly retained their magnetism, showing they had been hardened to a certain extent.†

Iron plays an important part in early Egyptian myths. Thus the firmament of heaven is described as a rectangular iron plate, each corner of which is supported by a pillar. The throne of the supreme god is likewise made of iron, ornamented with the faces of lions and feet like the hoofs of bulls.‡

* See p. 13.

† Petrie, *Journal of the Iron and Steel Institute*, 1912, No. I., p. 182.

‡ Budge, "A History of Egypt" (London, 1902), p. 136.

CHAPTER XIV.

IRON IN PALESTINE.

SHORTLY before the Israelites entered Palestine an energetic and cultured race, known in the Bible as the Philistines, had landed there and occupied the fertile regions on the shores of the Mediterranean Sea. They were non-Semitic and appear to have been in some way connected with Crete. The petty skirmishes between the Israelites and the Philistines, frequently alluded to in Holy Writ, are easily understood when one has once visited the country and traversed the bleak and barren heights occupied by the Israelites, and compared them with the fertile maritime plains below owned by the Philistines! As Macalister * quaintly puts it, "the promise of 'a land flowing with milk and honey' was not made to a crowd of beef-fed excursionists, coming from cultivated and developed lands of the modern West, but to tribes of half-starved wanderers, fighting their way from oasis to oasis over sterile sands." Hence, if the barren heights of Judah seemed to flow with milk and honey, how much more so would the maritime plain!

It is generally acknowledged that the Philistines introduced the use of iron into Palestine, but it is not improbable that the metal was known many years prior to this. The oldest specimens of iron hitherto found in Palestine are two wedge-shaped lumps found at the

* Macalister, "A History of Civilisation in Palestine" (C.U.P., 1921), p. 29.

bottom of the sloping part of the water-passage at Gezer.* The passage had been sealed up prior to 1250 B.C., so that the pieces of metal evidently date back to a time many years anterior to that at which iron came into general use in the country.

An obscure passage in the Book of Samuel reads as follows (1 Samuel, xiii., 19-22) :

"Now there was no smith found throughout all the land of Israel: for the Philistines said, Lest the Hebrews make them swords or spears :

But all the Israelites went down to the Philistines, to sharpen every man his share, and his coulter, and his axe, and his mattock.

So it came to pass in the day of battle, that there was neither sword nor spear found in the hand of any of the people that were with Saul and Jonathan: but with Saul and with Jonathan his son was there found."

The above passage clearly indicates that the Philistines were not only acquainted with iron, but had been careful to retain the monopoly of working this new metal, with the result that no smith was in Israel, and none save the King and his son possessed iron swords: "all had to make shift with ox-goads or other agricultural implements. The passage asserts almost in as many words that the Hebrews were still in the Bronze, the Philistines already in the Iron Age.

"The break-up of the Philistine domination removed the embargo on the new metal, and when David was on the throne its use became general. With the spread of iron, flint—which . . . was still used as a material for rough cutting implements—was quickly discarded." † The

* Macalister, *Palestine Exploration Fund*, Quarterly Statement, 1908, p. 1.

† Macalister, "A History of Civilisation in Palestine" (C.U.P., 1921), p. 60.

results of excavations in modern times point to the same conclusion.

There are several other interesting allusions to iron in Holy Writ, although but few of these are of really early date. Thus we read * that Og, King of Bashan, a city of the Amorites, possessed an iron bedstead. The actual dimensions are given, for Og was a giant. "Behold, his bedstead was a bedstead of iron . . . nine cubits was the length thereof, and four cubits the breadth of it, after the cubit of a man." Assuming the cubit to be 20·6 inches, the dimensions of the bed would be 15 by 7 feet. No doubt the word rendered *bed* would have been more correctly translated *bier*, or *sarcophagus*, for beds such as we know them were not then used. That the king should have been laid on a bier was quite a normal occurrence, and probably it would not have been recorded had it not been for the exceptional circumstances that the bier was made of iron.†

This account may, however, be a later addition to the MS., and "it would be rash to conclude from it alone that when the Israelites came out of Egypt into Canaan, the people of that land were working iron," ‡ though, of course, they may have been.

The great mound of Tel el Hesy, the Lachish of the Old Testament, affords a capital example of the manner in which the debris of successive towns built one upon the other has collected during many centuries in fairly well marked layers, enabling the antiquary to study stage by stage the gradual upward progress of civilisation. In his

* Deut. iii. 11, R.V.

† See *Encyclopædia Biblica* (Black, MCML.), vol. i., article "Bed."

‡ Ridgeway, "The Early Age of Greece" (Cambridge University Press, 1901), vol. i., p. 617.

description of this Gladstone* writes: "When Joshua, after the decisive victory of Bethhoron, led his troops to the plain in the south-west corner of Palestine, he besieged and took Lachish,† a city of the Amorites. It then became an important stronghold of the Israelites: its vicissitudes are frequently mentioned at various dates of the sacred history, as well as on the Tel el Amarna tablets. . . . In the remains of the Amorite city (perhaps 1500 B.C.) there are large rough weapons of war, made of copper without admixture with tin; above this, dating perhaps from 1250 to 800 B.C., appear bronze tools, with an occasional piece of silver or lead, but the bronze gradually becomes scarcer, its place being taken by iron,‡ till at the top of the mound there is little else than that metal. . . . About 700 B.C., Lachish was the headquarters of Sennacherib, during his invasion of Palestine," The city was finally deserted *circa* 400 B.C.

There was an old Canaanitish legend, to which reference is made in the book of Genesis,§ in which the humanised god Tubal-Cain is described as "an instructor of every artificer in brass and iron." The word *Tubal* is believed to be Babylonian and connected with *Gibil*, the god of solar fire. The Suffix *Cain* is missing from the Greek version and means "artificer." It was probably added to Tubal to explain why the hero was regarded as the father or instructor of smiths.|| Possibly in the earliest form of the Hebrew legend Tubal was the instructor of men in the art of making fire, probably by rubbing two

* J. H. Gladstone, *Nature*, 1898, vol. lvii., 594.

† See Joshua x. 31-32.

‡ See Bliss, "A Mound of Many Cities," p. 135.

§ Gen. iv. 22.

|| See *Encyclopædia Biblica* (Black, mcm.), vol. i., under "Cainites," section 10.

pieces of wood together, for this is the old Arabian method and appears in later times in connection with ritual. Enoch* recalls the general tradition that the first metal worker was a divine being, the fallen angel Azāzel being a teacher of the art.

For centuries the early Hebrews did not use war chariots, although the Canaanites used them largely. Sisera, for example, is stated to have had 900 of them.† though this may well be an exaggeration. The chariots were plated or studded externally with iron after the fashion of the Hittites rather than of the Egyptians.‡ Thus, the children of Joseph said to Joshua: "The Canaanites that dwell in the land of the valley have chariots of iron."§ Reference is made to the brilliant appearance of these chariots by Nahum,|| who says: "The chariots shall rage in the streets; . . . they shall seem like torches."

The possession of these chariots evidently gave the Canaanites a great military advantage over their adversaries, for we read ¶ that the Israelites "could not drive out the inhabitants of the valley, because they had chariots of iron." An account of the chariots also occurs in the historical inscriptions of Egypt, which are thus independent confirmation. The Canaanites obtained their iron from the mountains of Lebanon,** where smelting must have been carried on at a very early date.

David was familiar with iron. In the account of his fight with Goliath, the spear used by that giant is described †† as having a head weighing 600 shekels of iron.

* Enoch viii. 1.

† *Encyclopædia Biblica*, vol. i., under "Chariot."

‡ Nahum ii. 4.

** Deut. viii. 9. Jeremiah (xv. 12) speaks of iron from the north.

†† 1 Sam. xvii. 7.

† Judges iv. 3.

§ Joshua xvii. 16.

¶ Judges i. 19.

But this was apparently written some 200 years after the event had taken place.* In most respects Goliath was armed like the Homeric Heroes.† This is precisely what one might expect in view of the close connection between the Philistines and the Minoans of ancient Crete (see p. 179). In later years, when collecting material for the temple which his son Solomon was to build, David prepared, amongst other things,‡ “iron in abundance for the nails for the doors of the gates, and for the joinings.” Perhaps the most important reference in narratives concerning David occurs in the second book of Samuel,§ where the writer states that the people of Rabbah were, in accordance with the brutal customs of those times, put “under saws, and under harrows of iron, and under axes of iron.” From the fact that the metal is mentioned by name it may be inferred that bronze weapons were also in use.

It is an interesting tradition that no iron tool was used in the construction of Solomon's temple.|| We read “that there was neither hammer nor axe *nor any tool of iron* heard in the house, while it was in building.” The employment of metal would have been offensive to God who, in earlier days, had specially spoken against its use. Thus ¶ “if thou wilt make me an altar of stone, thou shalt not build it out of hewn stone; for if thou lift up thy tool upon it, thou hast polluted it.”

This is reminiscent of the habit of using stone knives for ritual, to which practice allusion has already been made (p. 32). To have used metal would have been profane. Solomon appears to have had iron workers of

* *Encyclopædia Biblica* (Black, MCML.), vol ii., under “Iron.”

† Ridgeway, “*Journal of Hellenic Studies*,” 1896, p. 114.

‡ 1 Chron. xxii. 3.

§ 2 Sam. xii. 31.

|| 1 Kings vi. 7.

¶ Exodus xx. 25.

his own, although he had to send to Hiram, King of Tyre, for his foreman or chief worker.*

In Jerusalem a dragoman recently informed the author of a curious belief which he stated to be prevalent amongst the Jews, namely that if the crevices in the ancient wall at the famous Wailing Place are completely filled with iron nails Jerusalem will once again be restored to the Jews. The authorities have very properly stopped the practice of plugging the walls with nails, which had in consequence come to be a nuisance, probably less from a fear that the superstition would be fulfilled than from a desire to prevent undue damage to the wall!

A crowd of questions instantly suggests itself to the enquiring mind. Would, for example, copper tacks be equally effective? If not, wherein lies the special significance of iron? To these, and a score of other questions of like nature, the author has been unable to find an answer.

From the time of Amos † iron was in general use amongst the Hebrews as well as the Syrians, and smelting furnaces were known to the later Hebrew writers.‡ The comparative values of different metals are instanced by Isaiah § in his description of the Zion of the future. "For brass," he says, "I will bring gold, and for iron I will bring silver, and for wood brass, and for stones iron." Steel is not specifically mentioned in the Old Testament, || but that is hardly to be wondered at.

A striking passage occurs in Jeremiah, ¶ in which the

* 2 Chron. ii. 7:

† See, for example, Amos i. 3; Micah iv. 13; Ezek. iv. 3; Isaiah xlv. 2; Jer. xvii. 1, etc.

‡ See Jer. xi. 4; Deut. iv. 20; 1 Kings viii. 51.

§ Isaiah lx. 17.

|| It is incorrect in 2 Sam. xxii. 35; Ps. xviii. 34, 35; Job xx. 24; Jer. xv. 12.

¶ Jer. i. 18.

strength of iron is emphasised. "For behold, I have made thee this day a defenced city, and an *iron pillar*, and brasen walls against the whole land. . . ."

The nails used in the crucifixion of Christ are usually regarded as having been made of iron. The "*Corona Ferrea*," known popularly as the **Crown of Lombardy**, consists of six golden plaques, enclosing an iron band, which latter, according to a pretty legend, was made from nails used in the crucifixion of Christ, and to this may be attributed the veneration in which the crown has been held. Whatever the origin of the band, the iron is fairly ancient, for the crown was presented in the seventh century to Queen Theodolinda by Pope Gregory the Great. It is kept at Monza, near Milan, enclosed in the hollow of an ornamental cross in the Cathedral. So late as 1878 it was brought out, to wit at the Funeral of Victor Emanuel, when it was placed on his bier, saluted by the troops, and accorded royal honours.* It was used also at the coronation of Napoleon at Milan in 1805.†

Iron and the Koran.—Iron is occasionally referred to in the Koran,‡ which was written in the early part of the seventh century. In the eighteenth Sura is a curious reference to Dhoulkarnain, by which name Alexander the Great is probably meant. He desired to build a wall from the west shore of the Caspian Sea to the Pontus Euxinus in order to hold the people of Eastern Asia in check. According to the Koran, Dhoulkarnain said, "'but help me strenuously, and I will set a barrier between you and them. Bring me blocks of iron'—until when it filled the space between the mountain sides—'Ply,' said he, 'your

* See Davenport, "*Jewellery*," p. 65 (Methuen, 1913).

† William Jones, "*Crowns and Coronations*" (London 1883), p. 366.

‡ See Rodwell's translation, Suras xvii. 53; xviii. 95; xxii. 21; xxxiv. 10; lvii. 25.

bellows,' until when he had made it red with heat, he said, 'Bring me molten brass that I may pour upon it.' And Gog and Magog were not able to scale it, neither were they able to dig through it."

Very probably the word translated *brass* would have been more correctly rendered as *bronze*.* By Gog and Magog are meant the enemy, that is, the barbarous inhabitants of Eastern Asia, the Arabic words being yadjoudj and madhoudj.*

Again, in Sura xxxiv. we are told that "of old bestowed we on David a gift, our special boon :—'Ye mountains and ye birds answer his songs of praise.' And we made the iron soft for him :—'Make coats of mail, and arrange its plates ; and work ye righteousness ; for I behold your actions.'

"And unto Solomon did we subject the wind, which travelled in the morning a month's journey, and a month's journey in the evening. And we made a fountain of molten brass to flow for him."

* Compare p. 73.

CHAPTER XV.

IRON IN MESOPOTAMIA.

THE Near East has witnessed the rise and fall of many an ancient civilisation. Different peoples with diverse tongues, and varying customs have met and traded, have fought and conquered or succumbed, upon this ancient soil. Empire has replaced empire, each in turn to die away and be forgotten, whilst Western Europe was still for the most part labouring in the throes of savagery. Now the position is reversed. Emissaries from the Western Civilisation, with pick and shovel, are unearthing the ruins of ancient palaces and cities, unravelling the history of the past. The great deeds of kings and rulers, for centuries sunk into oblivion, are being retold. Each year the story becomes more complete, although with increasing knowledge the vast amount of history yet to be unfolded seems likewise to increase.

In the region now known as Mesopotamia the Assyrians became an important factor about 1700 B.C., and were predominant about 1275 B.C.

One of the most famous of the early Assyrian kings was Tiglath Pileser I., who reigned about B.C. 1100, and was the contemporary of Nebuchadnezzar, King of Babylon, B.C. 1120. If, as explained below, a certain obscure passage in an account of this king's conquest is ultimately found to refer to iron, this will be the first instance in which the metal is specifically mentioned in Assyrian. The passage in question reads as follows: "Four wild

oxen, great and mighty, in the waste land, in the land of Mitauni near by Araziki, which lies before



Fig. 13.—Mesopotamia.

the Hattiland, I slew with mighty blows Sukuth parzilli."

In the words of Ridgeway,* "The last two words are taken to mean 'with arrows of iron' or 'tipped with iron.' It may be that the bows were of iron, but this is very doubtful. The doubt about the passage lies in the fact that *parzilli* is written ideographically, and its ideogram is the same as that of the god *Ninip*, who was god of war and hunting. Moreover *Sukuthe* is generally used to denote property, so that a very likely rendering would be 'mighty bows, the property (i.e., ideal weapons) of *Ninip*.' . . . It is therefore quite likely that this is not a case of iron at all."

It should be explained that the Babylonian god *Ninip*, also known as *Adar* and *Uras*, was, like *Thor* of the Scandinavians, the champion of the gods. The Assyrians specially loved to worship him, for they were essentially a military race. *Ninip* was also known as "lord of the pig," a title that it was found convenient to forget during Semitic periods of Chaldean History. This latter title connects *Ninip* with *Arês* who, according to Greek mythology, assumed the form of a wild boar and slew *Tammuz*, the Sun-god. *Ninip* was identified with iron under the name *Baru* or *An-bar*. *Bar* means that which shines, an Accadian word written with the determinative *an* meaning divinity, and is taken by some authorities as indicating the meteoric origin of the first iron worked in Babylonia.†

In 885 B.C. *Ashur-nasir-pal* ascended the throne, and began to extend his empire in a northerly direction. He transferred his government from *Asshur*, the ancient capital, to *Calah*, a city founded by *Shalmaneser I.*,

* Ridgeway, "The Early Age of Greece" (Cambridge University Press, 1901), vol. i., note, p. 616.

† Sayce, "Lectures on the Origin and Growth of Religion" (Williams and Norgate, 1887), p. 153.

circa B.C. 1300. Calah lay some 40 miles further up the Tigris, the site being marked by the modern village of Nimrud. Here Ashur-nasir-pal built a great palace—the North-west Palace unearthed by Layard in 1845, who found considerable quantities of iron among the ruins. These are described in the sequel (see p. 185).

Ashur-nasir-pal was one of the greatest of the Assyrian kings. In one respect his methods differed fundamentally from those of his predecessors* “who went a-raiding to plunder, assault, destroy, or receive submissive payments, and, their ends achieved, returned without imposing permanent garrisons of their own followers, permanent vice-roys or even a permanent tributary burden, to hinder the stricken foe from returning to his way till his turn should come to be raided again.”

Ashur-nasir-pal, on the other hand, and, in due course, his son Shalmaneser II., consolidated their empire by fortifying and garrisoning towns holding strategic positions, thereby bringing the inhabitants permanently under control.

During one of his campaigns Ashur-nasir-pal states that he had to cut a way through forests for his chariots, picks of bronze and *axes of iron* being used for the purpose. This, says Ridgeway,† “is the earliest ascertained date for the use of iron by the Assyrians.” Tiglath Pileser I., who reigned *circa* 1120 B.C., gives a similar account of having to make roads through difficult country. Only bronze picks, however, are mentioned by him.

Sargon II., B.C. 722 to 705, was the first of the Assyrian monarchs to encounter the Egyptians, who had allied themselves with the **Philistines**. These latter were a non-Semitic and highly civilised race, in some way connected

* Hogarth, “The Ancient East” (Williams and Norgate, 1914), p. 25.

† Ridgeway, *opus cit.*, p. 615.

with the ancient Minoans of Crete, as were also perhaps the Phœnicians further north. The Philistines had settled on the fertile maritime plains of the Palestinian coast shortly before the Israelites emerged from the desert to occupy the central hills. If Sargon was a great warrior he was also a great builder. He erected a palace at Khorsabad, not far from Nineveh; the remains of which were excavated by Botta. At the present time Khorsabad is a small village built on a mound a few miles north of Mosul. Excavations on this side were begun by M. Botta, French Consul at Mosul, in 1843, and the story of his discoveries reads like a romance.* Knowing that Botta was interested in stones bearing inscriptions and, above all, hearing that he was accustomed to pay for them, the local inhabitants constantly brought him specimens. In December, 1842, a man from Khorsabad brought him two large bricks, inscribed with cuneiform or wedge-shaped markings, which had been unearthed near his village, and offered to bring as many more as Botta desired. Although by no means sanguine of success, Botta, the following March, sent one or two workmen to the village to explore, and, after overcoming a little opposition from the inhabitants, a well was sunk into the mound. Fortune had led them to an eminently suitable site, for the excavation had only proceeded to a small distance below the surface when a wall was laid bare, built of sculptured slabs of gypsum. Upon hearing the good news Botta hastened to the spot and directed his men to excavate further in the direction of the wall. It was soon realised that the remains of a room had been unearthed, the walls of which were covered with sculptured

* Delightful accounts are given in "Nineveh and its Remains," by Layard (Murray, 1849), vol. i., and "Nineveh and its Palaces," by Bonomi (London, 1852).

representations of battles, sieges, and the like. Although unconscious of the fact at the time, he had discovered an Assyrian building, probably the first to be viewed by man since the fall of the Assyrian Empire.

Botta, however, did realise that his discoveries were of exceptional importance, and hastened to acquaint the principal scientific authorities in France with his success. Up till then the work had been carried on at his own expense ; but his resources were slender, and had it not been for a timely grant from the French Government in May of the same year, the work could hardly have continued.

Financial difficulties being removed, Botta had nevertheless numerous obstacles to encounter. "The marshy environs of the village of Khorsabad have a proverbial reputation for insalubrity—a reputation which was fully justified by his own personal experience, and by that of the workmen employed : for they all, in turns, felt its dangerous effects, and on one occasion the antiquary himself was very nearly falling a victim. But this was the least of his difficulties ; the unfavourable disposition of the local authorities was one which caused even more uneasiness, and one which was most difficult to surmount. It is a well-known fact that the Moslems, too ignorant themselves to understand the real motives of scientific researches, always attribute them to cupidity, which is the only spring of their own actions. Not being able to comprehend that the sums laid out are for the purpose of obtaining ancient remains, they believed that the search was for treasures. The inscriptions, copied with so much care, are in their eyes the talismanic guardians of these treasures, or point out the spots where they are concealed. . . .

"These absurd prejudices could not fail to influence

the avaricious and suspicious mind of Mohammed Pasha, who was then governor of the province of Mosul, and it was not long ere he began to grow uneasy at the researches which he had at first authorised. Taken up with the idea of the treasures hidden in the ruins which were being brought to light, he at first confined himself to having the workmen watched by guards, and when the slightest object formed of metal was found in the course of the excavations, it was seized and carried to him. These relics he submitted to every possible kind of proof to convince himself that they were not gold ; and then fancying that, despite this watching, the men who were employed might still succeed in keeping from him objects of value, he threatened them with the torture to make them reveal the existence of these imaginary treasures. Several of the workmen were, in consequence, on the point of leaving such service, notwithstanding all the assurances of protection Botta could give them, so well did they know the cruel disposition of Mohammed Pasha. Each day threatened some fresh combat, and Botta, who had continually to recommence his negotiations, would perhaps have been driven to throw the matter up in disgust, had he not been encouraged by the certainty of the extreme interest of his discovery. The works, however, although often interrupted by these petty annoyances, gradually advanced until about the commencement of the month of October, 1843, when the Pasha, in obedience perhaps to hints emanating from Constantinople, formally prohibited all further search. Some pretext or other was necessary, but a Turkish governor is never at fault in this respect, and the following is the one he invented ; Botta had built, with his express permission, a small house at Khorsabad, in order that he might have a place in which to stop when he visited the ruins. The Pasha pre-

tended that this house was a fortress erected to command the country; he informed his government of this grave fact, and the innocent researches of this zealous antiquary suddenly assumed the proportions of an international question!"*

Sufficient has now been said to indicate the nature of the difficulties and vexatious delays which the early excavators had to encounter. But courage, patience, and perseverance carried the day. Botta succeeded in unearthing what were afterwards proved to be the ruins of the Palace of Sargon, King of Assyria, B.C. 722 to 705. The sculptured blocks, huge though they were, were transported to Bagdad and ultimately shipped to France, being unloaded in December, 1846, and deposited in the Louvre Museum, Paris—the first collection of Assyrian antiquities that had ever been brought to Europe.

In the ruins, Victor Place† "found a storehouse containing, according to his estimation, not less than 160,000 kilogrammes of iron.‡ The greater part consisted of iron bars from 12 to 19 inches in length, and $2\frac{3}{4}$ to $5\frac{1}{2}$ inches in thickness. They were roughly drawn out at each end and pierced with a hole (Fig. 14), and weighed from about 8 to 44 lbs. Place supposed them to be work tools of some kind, but they are really bars of iron forged at the furnace of the mines into this shape for convenience of transport by men, horses, or camels.

"It is worthy of note here that similar forms survived for iron for transport and trading in Roman times, and even up to thirty or forty years ago in Finland and Sweden.

"The collection was chiefly a store of unworked iron held in readiness by the king for the instruments of war

* Bonomi, *opus cit.*, pp. 13, 14.

† See Gowland, *loc. cit.*, p. 281.

‡ Roughly 150 tons.

and for building construction. It contained also, however, many kinds of finished iron articles, such as chains, horse-bits, etc., all arranged in regular order.

"This vast accumulation of iron indicates incontestably that the metal had been in use for many centuries previous to the time of Sargon, so that it will not be unreasonable to assume that the Assyrians were acquainted with iron certainly earlier than 1500 or even 2000 B.C."

Sargon also restored the palace that Ashur-nasir-pal had built at Nimrud (Calah) 150 years before him, and converted it into a storehouse for treasures and spoil collected during his campaigns.

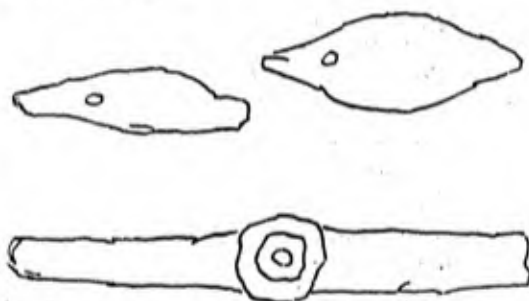


Fig. 14.—Iron found at Khorsabad.

Layard, in his fascinating work on "Nineveh and Its Remains," describes his early excavations at Nimrud, the site of ancient Calah, which was built, according to Holy Writ,* by Nimrod—"a mighty hunter before the Lord" who "went forth into Assyria, and builded Nineveh, and Rehoboth-Ir, and Calah, and Resen between Nineveh and Calah (the same is a great city)." It lies some 20 miles to the south of Nineveh, near the junction of the Tigris and the Upper Zab Rivers. According to an

* See Genesis x. 9, 11 (R.V.).

inscription of Ashur-nasir-pal, king of Assyria, *circa* B.C. 885, it had been founded by Shalmaneser the First, an early king of Assyria, *circa* B.C. 1300, and was now made the new capital of Assyria to replace the more ancient capital, Asshur, some forty miles further south down the Tigris. This was necessitated by the growth of Assyria in the north and northwest directions, which made it difficult to control the empire from Asshur. The natives call the place Nimrud, because local tradition ascribes its origin to Athur, one of the generals of Nimrod.

Layard was faced with obstacles due to ignorance and prejudice similar to those encountered by Botta. He began his excavations in November 1845, and on the 28th of that month his men unearthed, amid great excitement, the first bas-relief. It was a battle scene. "Two chariots, drawn by horses richly caparisoned, were each occupied by a group of three warriors; the principal person in both groups was beardless and evidently a eunuch. He was clothed in a complete suit of mail, and wore a pointed helmet on his head, from the sides of which fell lappets covering the ears, the lower part of the face, and the neck." *

The question naturally arises: of what were the suits of mail and the pointed helmets made? Were they of metal? If so, was the metal bronze or iron? Or were the suits of mail composed of hardened leather, like the scale armour found by Sir Arthur Stein in his excavations of the ruined fort of Miran? (See p. 196).

A satisfactory answer to this query is to be found in Layard's description of the remains of the metallic articles actually found amongst the ruins.

"As we approached the floor . . .," Layard † writes,

* Layard, "Nineveh and its Remains" (Murray, 1849), vol. i., p. 40.

† Layard, *opus cit.*, vol. i., p. 340.

" a large quantity of iron was found amongst the rubbish, and I soon recognised in it the scales of the armour represented on the sculptures. Each scale was separate and of iron, from two to three inches in length, rounded at one end and square at the other, with a raised or embossed line in the centre. The iron was covered with rust. . . . As the earth was removed, other portions of armour were found, some of copper, others of iron, and others of iron inlaid with copper. At length a perfect helmet (representing in shape and in the ornaments the pointed helmet represented in bas-reliefs) was discovered. When first separated from the earth it was perfect, but immediately fell to pieces. . . . The lines which are seen round the lower part of the pointed helmets in the sculptures are thin strips of copper, inlaid in the iron. Several helmets of other shapes, some with the arched crest, were also uncovered, but they fell to pieces as soon as exposed . . . for the iron was in so complete a state of decomposition that it crumbled away on being touched."

Many other metal objects of interest were likewise found,* such as " swords, daggers, shields, and the heads of spears and arrows, which, being chiefly of iron, fell to pieces almost as soon as exposed to the air. . . . The shields stood upright, one against the other, supported by a square piece of brickwork, and were so much decayed that with great difficulty two were removed and sent to England. They are of bronze and circular, the rim bending inwards, and forming a deep groove round the edge. The handles are of iron, and fastened by six bosses or nails, the heads of which form an ornament on the outer face of the shield,"—which may have been the " bosses of the bucklers " referred to in Job xv. 25.

* Layard, " Discoveries in the Ruins of Nineveh and Babylon " (Murray, 1853), p. 194.

"Although their weight must have impeded their movements of an armed warrior, the Assyrian spearmen are constantly represented in the bas-reliefs with them. Such, too, were probably the bucklers that Solomon hung on his towers."^{*}

A number of thin rods were found, adhering together in bundles, amongst the arms, and it is suggested that they may have been the shafts of arrows. Perhaps reference to this kind of shaft is intended in Isaiah xlix. 2, where the prophet claims that the Lord hath "made me a polished shaft; in his quiver hath he hid me."[†]

A large blunt spear-head was also found, such as were used during sieges to force stones from the walls of besieged cities.

Among the iron instruments—as distinct from weapons—found at Nimrud were the head of a pick; a double-handed saw, some three and a half feet in length, with serrated edge; and several objects resembling the heads of sledge hammers.

A very remarkable object was a small casting in the shape of the fore leg of a bull. It formed the foot of a stand, consisting of a ring of iron, resting on three feet of bronze. It was deeply corroded in places, and posteriorly was fissured at the upper part. A section was made by Percy, which disclosed a central piece of iron, over which the bronze had been cast. At the upper part, where it had broken off, the iron had rusted, and so produced the crack above mentioned. The casting was sound, and the contact perfect between the iron and surrounding bronze. It was evident on inspection that the bronze had been cast round the iron, and that the iron had not been let into the bronze."

^{*} See 1 Kings x. 16, 17; xiv. 25, 26.

[†] See also Jeremiah li. 11. Ezekiel xxi. 21.

The bronze had the following composition :

Copper,	88.37 per cent.
Tin,	11.33 „
Total,	99.70 „

Was the iron used to save the bronze, or was it because it was necessary to the construction? Percy assumes the latter and suggests also that the contrast of iron and bronze may have been regarded as ornamental.*

Iron ore is found in the Tiyari Mountains, north-east of Nineveh, and is a source of iron at the present day.† It may also have been worked by the Assyrians, although, as mentioned above, iron was largely obtained by them as tribute from subject nations.

Herodotus makes several interesting allusions to the use of iron by the Persians and Assyrians. Xerxes was king of Babylon from B.C. 485 to B.C. 455. He collected a large army together and marched against Greece. The troops under his banner numbering, perhaps, some 300,000 in the land forces,‡ were arranged according to their nationalities, and Herodotus describes their equipment as follows :

“Now these were the nations that took part in this expedition. The Persians; who wore on their heads the soft hat called the tiara, and about their bodies, tunics with sleeves of divers colours, having *iron scales* upon them, like the scales of a fish. Their legs were protected by trousers; and they bore wicker shields for bucklers; their quivers hanging at their backs, and their arms being a short spear, a bow of uncommon size, and arrows of

* See Layard, “Discoveries in the Ruins of Nineveh and Babylon” (Murray, 1853), Appendix III. by Dr. Percy.

† Gowland, *opus cit.*, p. 281.

‡ Herodotus (Book vii., chap. 60) states 1,700,000. But modern historians divide this number by 3.

reed. They had likewise daggers suspended from their girdles along their right thighs. . . .

"The Medes had exactly the same equipment as the Persians, and, indeed, the dress common to both is not so much Persian as Median. . . .

"The Assyrians went to the war with helmets upon their heads made of brass, and plaited in a strange fashion which is not easy to describe. They carried shields, lances and daggers very like the Egyptians, but in addition they had *wooden clubs knotted with iron*, and linen corselets. . . . "

It is interesting to note that the Indians carried bows of cane and arrows also of cane but tipped with iron, whereas the Ethiopian arrows were tipped with stone.

We are reminded of Pandarus who, nearly 1,000 years before the time of Xerxes, used an arrow with an iron head (see p. 75).

Finally, Herodotus states that the Persian horsemen "wore upon their heads devices fashioned with a hammer in brass or steel."

CHAPTER XVI.

IRON IN AFRICA.

THE natives of Africa, Egypt excepted, seem to have had no copper or bronze age. They passed directly, like the inhabitants of ancient Spain, into the iron age. Nevertheless, "so far as metallurgical evidence may be relied on, the extraction of iron from its ores was carried on at a very remote date. The seats of an ancient iron industry marked by accumulations of slags and debris, are so widely distributed in that continent that it must date from a very early period, and, according to Beck,* must have been indigenous."†

In the annual report of the Gold Coast for 1922-23 reference is made to the discovery of large deposits of bauxite or hydrated aluminium oxide on a range of hills. On one of the hills there is a shallow trench, 150 yards long, from which, apparently in local prehistoric times, highly ferriferous bauxite had been picked and smelted for iron. The remoteness of the period when these operations were in progress is suggested by the occurrence of pieces of slag at a depth of eight feet in the old terrace of a stream at the foot of the hill. This slag was found in detritus that had obviously been undisturbed since its original deposition.

* Beck, "Geschichte des Eisens" (Vieweg).

† Gowland, "Huxley Memorial Lecture for 1912," Royal Anthropological Institute of Great Britain and Ireland, p. 285.

Schweinfurth,* who during the years 1868 to 1871 was engaged in the exploration of Central Africa, gives several highly interesting accounts of the different methods by which the savage tribes made their iron. No doubt their prehistoric ancestors prepared iron in a closely similar manner. The furnace used by the Dyoor—a name meaning men of the woods or wild men—is made of clay. In shape it is conical, as shown in Fig. 15, but the tendency of the clay to crack limits the height of the furnace to about 4 feet. Fragments of ore are thrown into the cup-



Fig. 15.—A Dyoor Furnace.

shaped portion at the top, the lower conical part having first been packed with charcoal. At the base are four openings, one of which is larger than the others, and is used for the removal of the slag, etc. The other three are to admit the long tewel irons, or pokers, which reach to the middle of the bottom, and keep the aperture free for the admission of air. Without stoking the openings would very soon become blocked up with slag. In reply to his inquiry, Schweinfurth was informed that bellows are

* Schweinfurth, *The Heart of Africa* (Sampson Low), p. 81.

never employed, as it was found that too fierce a fire was injurious and caused a loss of metal. It would be interesting to inquire if the supposed injurious effect was really due to the production of a little cast iron, which would be unworkable, and therefore a loss to the smelter. When the flames have penetrated through the mass of ore and escape at the top of the furnace the reduction is presumed to be satisfactory. The metal has now sunk down into the hearth, is reduced a second time, and the heavy portion of the resulting product, which is detached in little leaflets

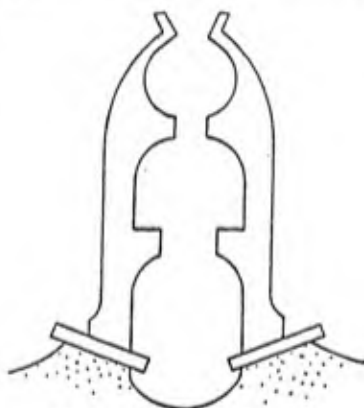


Fig. 16.—A Bongo Furnace.

and granules, is further heated in clay crucibles. The red-hot particles of metal are beaten into one compact mass with stone hammers, and by repeated hammering lose much of their impurity. The final product is stated by Schweinfurth to be very homogeneous and malleable.

The usual shape in which the raw material is used as a medium of exchange is in spear heads or in spades. Spear heads are about $\frac{3}{4}$ yard in length, and serve as currency throughout the Upper Nile. The Bongo, another tribe in

Central Africa, prepare their iron in a somewhat more advanced manner.* After the harvest has been gathered in and the rains are over the clay furnaces are erected, of a shape shown in Fig. 16. They are 5 feet in height, and are divided into three compartments, the middle one of which is filled with alternate layers of fuel and ore. The other two contain fuel only. The lowest section has four holes for the reception of tewels, and through which also a blast is applied by means of bellows. A fifth hole serves for the removal of the metal. The raw metal obtained in this way is exhibited in three shapes :—

1. *Mahee*.—Spear heads 1 to 2 feet in length analogous to those of the Dyoor already mentioned.

2. *Loggoh kullutty*, and

3. *Loggoh* or *Loggoh melot*, the spade-like articles to which reference has already been made in an earlier chapter (see p. 66).

In passing it is of interest to recall that in Livingstone's time (1843) a curious custom prevailed amongst the Bakhlata in Bechuanaland, according to which married men were prohibited from going to their little iron works through fear that they would bewitch the metal.† Livingstone, however, gained admission, being a bachelor at that time.

* Schweinfurth, *loc. cit.*, p. 124.

† Blaikie, "Personal Life of David Livingstone" (Murray, 1913), p. 43.

CHAPTER XVII.

IRON IN CHINA AND JAPAN.

It is difficult to obtain precise information as to how long the Chinese have been familiar with iron; probably in common with many other nations they were acquainted with the metal at a period long anterior to that at which it came into common use. The province of Shan Si has yielded iron from very remote times.*

The bronze age in China probably began about the time of the Emperor Ta-yü, that is, Yü the Great, *circa* 2200 B.C., and is believed † to have drawn to a close about 500 B.C. For religious purposes bronze was still the favoured metal, and the art of casting in bronze continued to improve for many centuries, attaining its zenith in the magnificent and gigantic castings of the Northern Wei (A.D. 386-535) and T'ang (A.D. 618-907) dynasties.

Prior to 500 B.C., however, iron appears to have found its way into use for agricultural and domestic purposes. During the reign of the Emperor Chuang-Wang, 696-682 B.C., a minor federal state, known as Ts'i, in the North-East of China, due East of the Yellow River, rose to considerable power. It was administered by Duke Huan whose prime Minister, Kuan-tzī, was a man of exceptional ability as a practical statesman. Kuan-tzī advised the Duke to levy taxes on salt and iron, which had hitherto been exempt. "How is this to be done?" enquired the

* R. A. Smith, "A Guide to the Antiquities of the Bronze Age" (British Museum, 1920), p. 2.

† Nature, 1918, cii., 250.

Duke,* to which Kuan-tzī replied, "In a family of ten individuals there will be ten consumers of salt; in a family of a hundred there will be a hundred consumers. A male adult will consume five pints or at least half that quantity every month; a female adult, three pints, or at least half of this; a child two pints, or at least half of this. These are the averages for salt consumption."

Kuan-tzī then proceeded to estimate the number of people in the state. "In a country of ten thousand chariots the number of consuming individuals may be set down at ten millions," he calculated, and so arrived at an estimate of the quantity of salt consumed *in toto* within the state. By levying a tax on the dealers, therefore, everybody would be compelled to pay his mite, according to the quantity of salt he consumed.

Similarly Kuan-tzī recommended the introduction of a tax upon the iron production of the state. "The officials in charge of the iron works," writes Hirth, "had reported that every woman in the country must have a needle and a knife; that every field labourer must have a plough, a spade, and a cooking pan, a cart, a hatchet, etc.—all these being necessities of life, a tax upon which would be a regular source of public revenue."

The result of this conversation between Kuan-tzī and the Duke led to the institution of salt and iron monopolies, under which the iron industry flourished both then and during succeeding centuries, for later governments found the revenue so profitable that they did all in their power to increase production and consumption of the metal. It will be observed that although Kuan-tzī mentions needles, knives, and agricultural implements, he does not mention the use of iron for swords or arms. Probably the explanation is precisely the same as that offered by Lang (see p.

* Hirth, "The Ancient History of China" (New York, 1908), p. 203.

77) in connection with the Homeric period, namely, that the metal was not as yet sufficiently reliable to be used for military purposes where great strength is required, coupled with a minimum thickness.

"Three hundred years later," writes Hirth, "we find King Kóu-tsién in the possession of certain magic swords, with which feats of wonder could be performed. It is distinctly stated that these were cast from tin and copper. But it is stated that the production of iron swords, alleged to possess magic qualities, excited the curiosity of the king of Ch'u, who consulted an expert named Fong-hu-tzī about them." This would appear to suggest that the Chinese metallurgist had now learned to carburise his iron, thus converting it into steel, which could be hardened by quenching.

Pliny* states that the best iron is that made by the Seres. This is identified as Chinese iron.

In the time of Marco Polo (1254 to 1324) curious superstitions survived as to the power or otherwise of iron to inflict wounds and death. Polo relates that, after the capture of a certain city, the troops of Cublāi-Khan, the Emperor of China, "beheaded all they took, except eight persons, which by an enchanted precious stone, enclosed in the right arm between the skin and the flesh, could not be wounded with iron; whereupon, with wooden clubs, at the command of the two barons, they were slain."†

Let us now turn south and westwards.

In his excavations of the ruined fort of Miran on the borders of Tibet and Chinese Turkestan, Stein found broken shafts of reed arrows and iron arrow-heads. Far more abundant were the relics of defensive armour in the form of lacquered pieces of leather, varying in size, but

* Pliny, Book xxxiv., chap. 41.

† See "Voyages and Travels of Marco Polo" (Cassell, 1886), p. 145.

all oblong, belonging to scale armour. Judging by the way in which the scales had been shed in the different rooms, and by their large number, Stein concludes that armour of lacquered leather must have been worn commonly at the period, namely during the eighth and ninth centuries A.D.

Similarly in his excavations of the Niya site, watered by the river Niya in Chinese Turkestan, Stein* found "pieces of a woollen pile carpet, embroidered leather and felt, plaited braids and cords, arrow-heads in bronze and iron, fragments of fine lacquer ware and broken implements in wood and horn."

"Quite at the bottom of the enclosure there turned up a small heap of corn, still in sheaves and in perfect preservation, and close to it the mummified bodies of two mice, which death had overtaken while nibbling at this store."

It would appear, therefore, that whilst iron had already been long known at this date, it had not come into very general use.

Gowland† states that "the Japanese when they migrated from the mainland were passing out of the Bronze Age stage of culture and entering the Iron Age, as but few weapons of bronze, only halberds and one or two swords, have been found, and these only in those parts of the islands which were first occupied by them. They had already become skilful workers in iron before they became dolmen builders, three or four centuries B.C. No weapons, except iron swords, spear-heads, and arrow-heads, have been found in the chambers of the dolmens, and all, more particularly the swords, are splendid examples of the work of the smith."

* M. A. Stein, "Ruins of Desert Cathay" (Macmillan, 1912), pp. 275, 352.

† Gowland, *loc. cit.*, p. 283.

The Chinese are generally supposed to have been acquainted with the compass at a very early date. The invention of "south-pointing chariots" is ascribed in the *Ku-Kin-Chu* of the Fourth Century A.D. to the legendary Emperor Huang-ti, circa 2704 to 2594 B.C. Again in the reign of Ch'öng-Wang, B.C. 1115 to 1079, the Duke of Chóu, uncle of the Emperor, is stated to have presented certain Ambassadors to the Imperial Court with "South-pointing chariots" to enable them to find their way back home.* This, however, even if correct, does not prove that the Chinese were acquainted with iron or steel, for the natural oxide, magnetite or lodestone, as its name implies, points itself north and south when freely suspended, just like magnetised steel; and, as has already been mentioned, ores of iron, including magnetic ores, are abundant in China. Benjamin† sums the position up very appropriately as follows: "To suspend an elongated piece of the stone and see it turn itself in a definite direction; or to do this repeatedly and with different pieces and thus learn that the phenomenon is true of this particular stone and not of other stones, obviously involves no necessary knowledge of its attractive effects on iron. Therefore, if we admit the possibility of sufficient intelligence in the race then living, we may conjecture that an acquaintance with magnetic polarity may have existed among the earliest peoples of which we have any tradition. I shall show hereafter that reason for such conjecture is by no means absent, which, if accepted, places human knowledge of the directive tendency of the lodestone not only far beyond the limits of history, but even suggests the utilisation of that know-

* See Hirth, *opus cit.*, pp. 126-136.

† Benjamin, "The Intellectual Rise in Electricity" (Longmans, 1895), p. 20.

ledge by wandering hordes for their actual guidance over the wildernesses of the earth, at the same extremely remote epoch."

CHAPTER XVIII.

IRON AND THE NEW WORLD.

WHEN in 1492 Christopher Columbus discovered the West Indies, he found them inhabited by a poor but friendly people. Those on the island he first visited, and which he christened San Salvador, he described as being well made, of good countenance, but with coarse hair and yellow colour.* They neither carried arms nor understood them, for when Columbus showed them swords they took hold of them by the blade and cut themselves. "They came swimming," he writes, "to the ship's boats where we were, and brought us parrots, cotton threads in balls, darts, and many other things, and bartered them with us for things which we gave them, such as bells and small glass beads." Their darts, however, were without iron, and some had a fish's tooth at the end. The Cubans, whom Columbus next visited, were familiar with gold, and, thus excited the cupidity of the Spanish, as might be expected.

In 1502, in the course of his fourth voyage, Columbus came across a canoe manned by 25 Indians who had come from the mainland on a trading expedition amongst the islands. Their cargo comprised cotton goods, swords of iron-wood, flint knives, axe-heads of copper and cacao, the last of which was entirely new to the Spaniards.

Evidently therefore the natives of the Islands and the

* See "The Life of Columbus," Sir Arthur Helps, 1869, chap. v.

mainland were only in the so-called chalcolithic stage of civilisation, and entirely ignorant of iron.

Iron in Mexico and Peru.—It has frequently been urged that the marvellous skill with which the blocks of granite used in the construction of Khufu's pyramid at Gizeh, in Egypt, postulates an early knowledge of iron by the Egyptians. This is not necessarily so, however, for it appears that wonderful carvings have been executed in granite, porphyry, emeralds, and other excessively hard materials by Mexicans and Peruvians at a time when they were entirely ignorant of iron. Referring to the Peruvians, Prescott says* :

"It was comparatively easy to cast and even to sculpture metallic substances, both of which they did with consummate skill. But that they should have shown the like facility in cutting the hardest substances, as emeralds and other precious stones, is not so easy to explain. Emeralds they obtained in considerable quantity from the barren district of Atacames, and this inflexible material seems to have been almost as ductile in the hands of the Peruvian artist as if it had been made of clay. *Yet the natives were unacquainted with the use of iron, though the soil was largely impregnated with it.* The tools used were of stone, or more frequently of copper. But the material on which they relied for the execution of their most difficult tasks was formed by combining a very small proportion of tin with copper. This composition gave a hardness to the metal which seems to have been little inferior to that of steel. With the aid of it, not only did the Peruvian artisan hew into shape porphyry and granite, but by his patient industry accomplished works which the European would not have ventured to under-

* Prescott, "The Conquest of Peru," 1847. See Dent's Everyman's Library, 1908, pp. 91-92. The italics are those of the present author.

take. Among the remains of the monuments of Cannar may be seen movable rings in the muzzles of animals, all nicely sculptured of one entire block of granite."

Similarly, in reference to the Mexicans, Prescott says* :

"It may seem extraordinary that no iron in the buildings themselves, nor iron tools, should have been discovered, considering that the materials used are chiefly granite, very hard, and carefully hewn and polished. Red copper chisels and axes have been picked up in the midst of large blocks of granite imperfectly cut, with fragments of pillars and architraves, in the quarries near Mitla. Tools of a similar kind have been discovered, also, in the quarries near Thebes ; and the difficulty, nay, impossibility of cutting such masses from the living rock, with any tools that we possess, except iron, has confirmed an ingenious writer in the supposition that this metal must have been employed by the Egyptians, but that its tendency to decomposition, especially in a nitrous soil, has prevented any specimens of it from being preserved.† Yet iron has been found, after the lapse of some thousands of years, in the remains of antiquity ; and it is certain that the Mexicans, down to the time of the Conquest, used only instruments of copper, with an alloy of tin, and a siliceous powder, to cut the hardest stones, and some of them of enormous dimensions. This fact, with the additional circumstance, that only similar tools have been found in Central America, strengthens the conclusion that iron was neither known there nor in ancient Egypt."

* Prescott, "The Conquest of Mexico," 1843. See Dent's Everyman's Library, p. 394.

† See p. 166.

CHAPTER XIX.

FINIS.

A BRIEF note on the discovery of cast iron and the development of the iron trade within more recent times will not be out of place, linking up the past with the present.

From prehistoric times right down to comparatively recent historic periods when iron has been made it has always been by direct reduction of ore. At first very primitive furnaces would be used, though the precise form has not been established. Perhaps the first iron furnace of the Britons was evolved from that employed in the extraction of tin. It may therefore have been a genuine British invention, like the water clocks referred to in a previous chapter. If so, it was developed quite independently of the simple low hearth furnaces which have been used on the Continent from very early times.

As metallurgical science improved, the furnaces would naturally be made bigger and more efficient. In Europe for many years the *Swedish* or *Osmund* furnace was employed.*

The ore, after having been dried by exposure to the air, was calcined in heaps, with wood as the fuel; the calcination was completed in two days. The ore was then smelted with charcoal in the usual way, the average output of iron being merely $1\frac{1}{2}$ tons per furnace per week.

* Percy, "Metallurgy—Iron and Steel" (Murray, 1864), p. 320.

In working up the bloom there was considerable loss, sometimes amounting to 50 per cent.

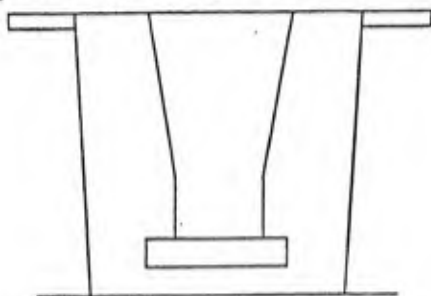


Fig. 17.—The Osmund Furnace.

The Osmund furnace was eventually succeeded by the German *Stückofen*—an ugly name, for which no English

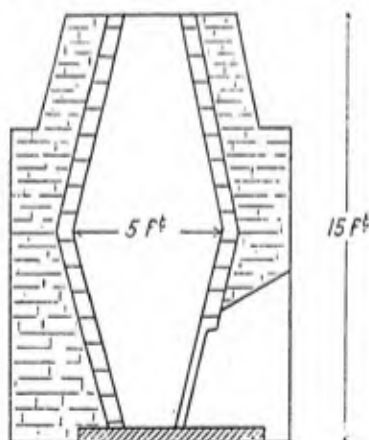


Fig. 18.—The Stückofen.

equivalent has been given. The name originates from that given to the mass of metal or "*Stück*" extracted

from the bottom of the furnace after smelting. This furnace resembles two Osmund furnaces, one inverted over the other, and is clearly the forerunner of our modern blast furnace. The taller the furnace the longer the metal remains in contact with the fuel—other things being equal. Consequently, the introduction of the Stückofen led to the production, by a series of oft-recurring accidents, of cast iron. As the height of the furnace increased cast iron became increasingly frequent until eventually it was the only product, as at the present time.

Cast iron does occasionally, of course, occur free in nature. A specimen of native cast iron was found about 15 years ago near Vladivostock, and contained—

Iron,	.	.	.	.	.	93.87 per cent.
Carbon (free),	.	.	.	.	.	2.87 ..
Carbon (combined),	.	.	.	.	.	0.33 ..
Silicon,	.	.	.	.	.	1.55 ..

together with small quantities of manganese and sulphur. It is believed to have been formed by the interaction of coal and iron ore in a sedimentary rock, induced by the heat from an intruded igneous rock.*

It is impossible to state exactly when cast iron came to be recognised as a form of iron of metallurgical importance. It appears to have been known in Sussex in 1350, and by 1400 was quite a common product. Sussex was at that time one of the chief homes of the iron industry, its stores of iron ore and wood providing the essentials. It was in the village of Buxted, not far from Crowborough, that

“Master Huggett and his man John
They did cast the first cannon.”

* Inostzanzeff, *Zeitschrift für Krystallographie und Mineralogie*, 1911, 50, 61.

At first cast iron was used exclusively for casting purposes. Its earliest application was on the Continent, but its use began to be general in this country about 1500. In 1516 a cast-iron gun called Basiliscus was made, weighing approximately 10,500 lbs. In 1588 the Spanish employed both bronze and cast-iron guns in their Armada, and some of these have since been raised from vessels sunk off the coast of Scotland when the fleet had been dispersed.

Eighteenth Century Developments.—In consequence of the gradual depletion of our supplies of wood, many attempts were made to utilise coal for the reduction of iron ores instead of charcoal, but it was not until about 1735 that the problem was satisfactorily solved, namely, by Abraham Darby, the younger, at Colebrooke, in Shropshire. Fifteen years later coal became a serious competitor with charcoal. In 1740 there were only 59 blast furnaces in England and Wales, the average weekly output being under 6 tons per furnace. In 1790 there were no fewer than 106 furnaces, 81 of which used coke, the remainder using charcoal. The average weekly output of the coke-fired furnaces was 17 tons per week.* In 1754 Darby † had some seven furnaces, and mechanically-driven engines to supply the blast. The grandfather of this Darby, namely, John Darby, brought over some Dutch brass founders, and built a foundry in Bristol. Here he experimented about the year 1706 with cast iron, endeavouring to obtain castings in this metal, but without success. His Welsh apprentice, John Thomas, thought he saw what was wrong, communicated his ideas to Abraham Darby, the elder son of John, and these two secretly cast the same night an iron pot. For more than a century the secret was jealously guarded, and the

* See Summary in *Nature*, 1910, vol. lxxxiii., p. 265.

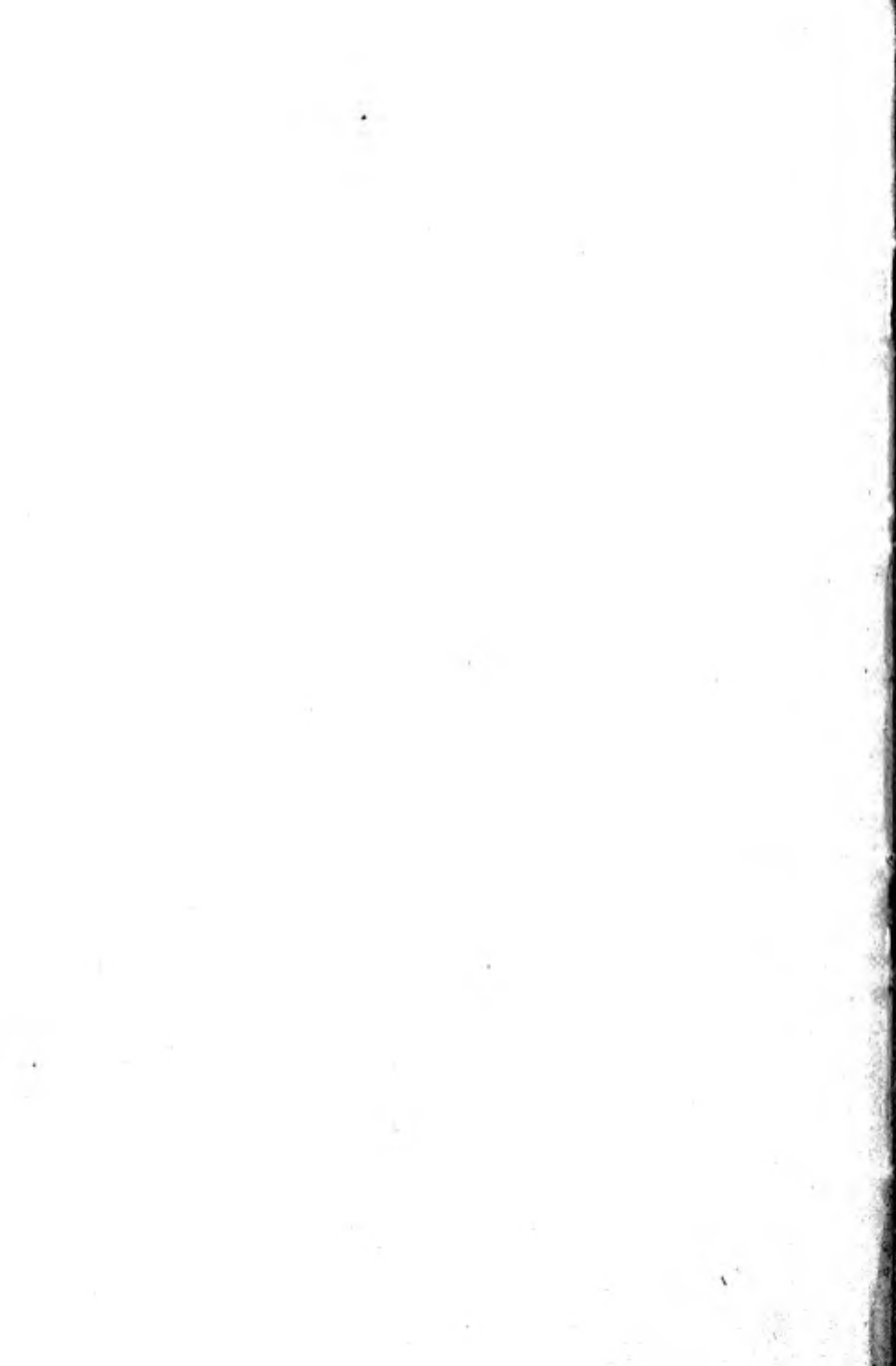
† Scrivenor, "History of the Iron Trade" (Longmans, 1854).

process was regularly carried out, at Colebrookdale, successively by John, by Abraham the elder, and Abraham the younger.

About 1740 Huntsman perfected his process of making cast steel—a process still in use—and in 1784 Henry Cort introduced the puddling process. Cast iron was now being used for a two-fold purpose. In addition to casting it found employ as the most suitable starting-point for the manufacture of iron and steel. Consequently the demand for cast iron increased by leaps and bounds.

In 1800, the United Kingdom produced about a quarter of a million tons of pig-iron; in 1850 this had increased to $2\frac{1}{4}$ million tons. From this time onwards the production increased rapidly to a maximum of 10,260,315 tons in 1913. Since then, owing to wars and social upheavals, the production has varied greatly, being 6,236,200 tons in 1925, the world's production for that year being estimated as 75 million tons.

It is thus evident that iron occupies a most important place in modern economics. The time spent in unravelling its ancient history and thereby throwing light upon the customs and manner of life of our early ancestors will not, we opine, be regarded as lost or wasted.



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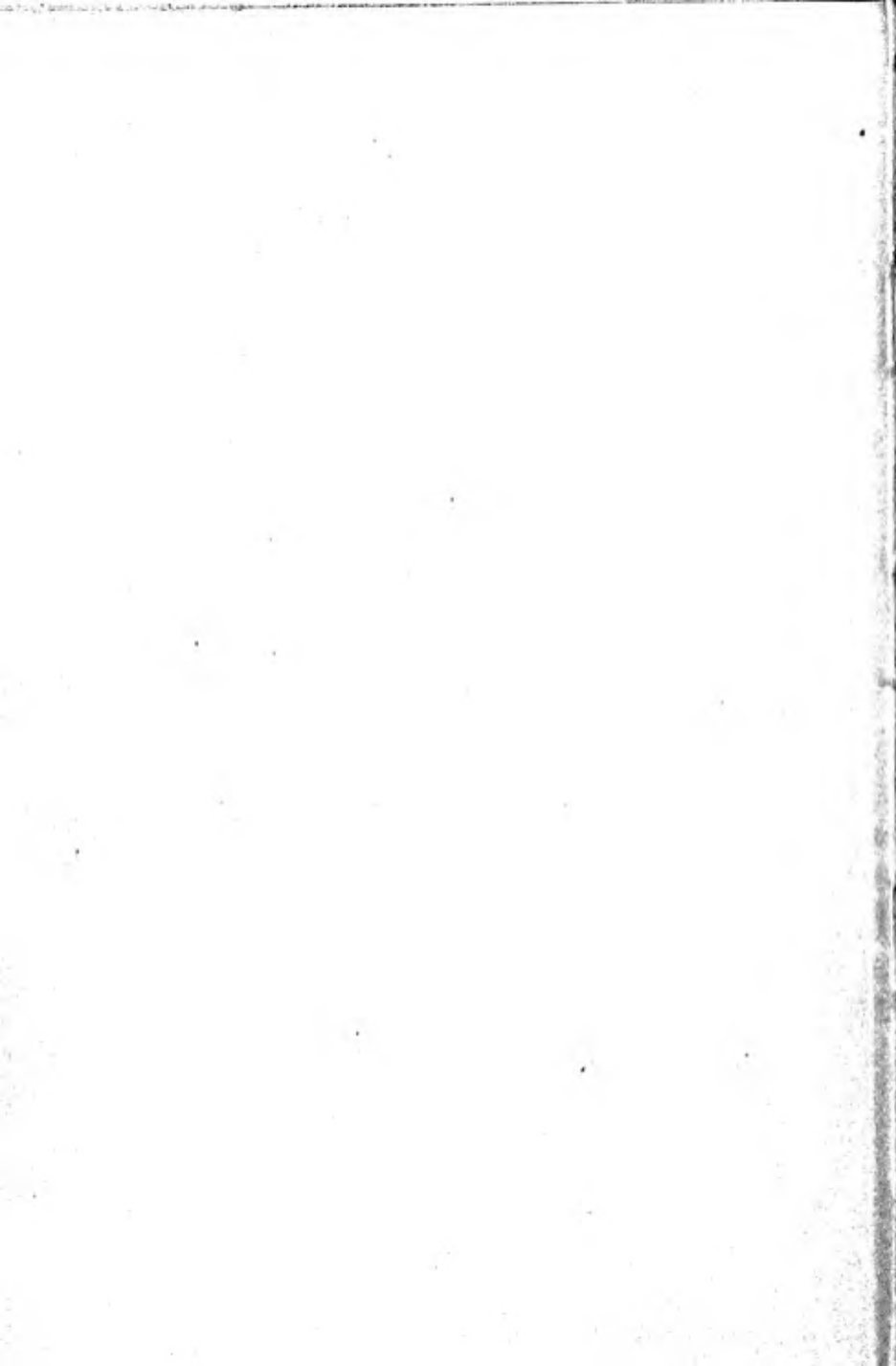
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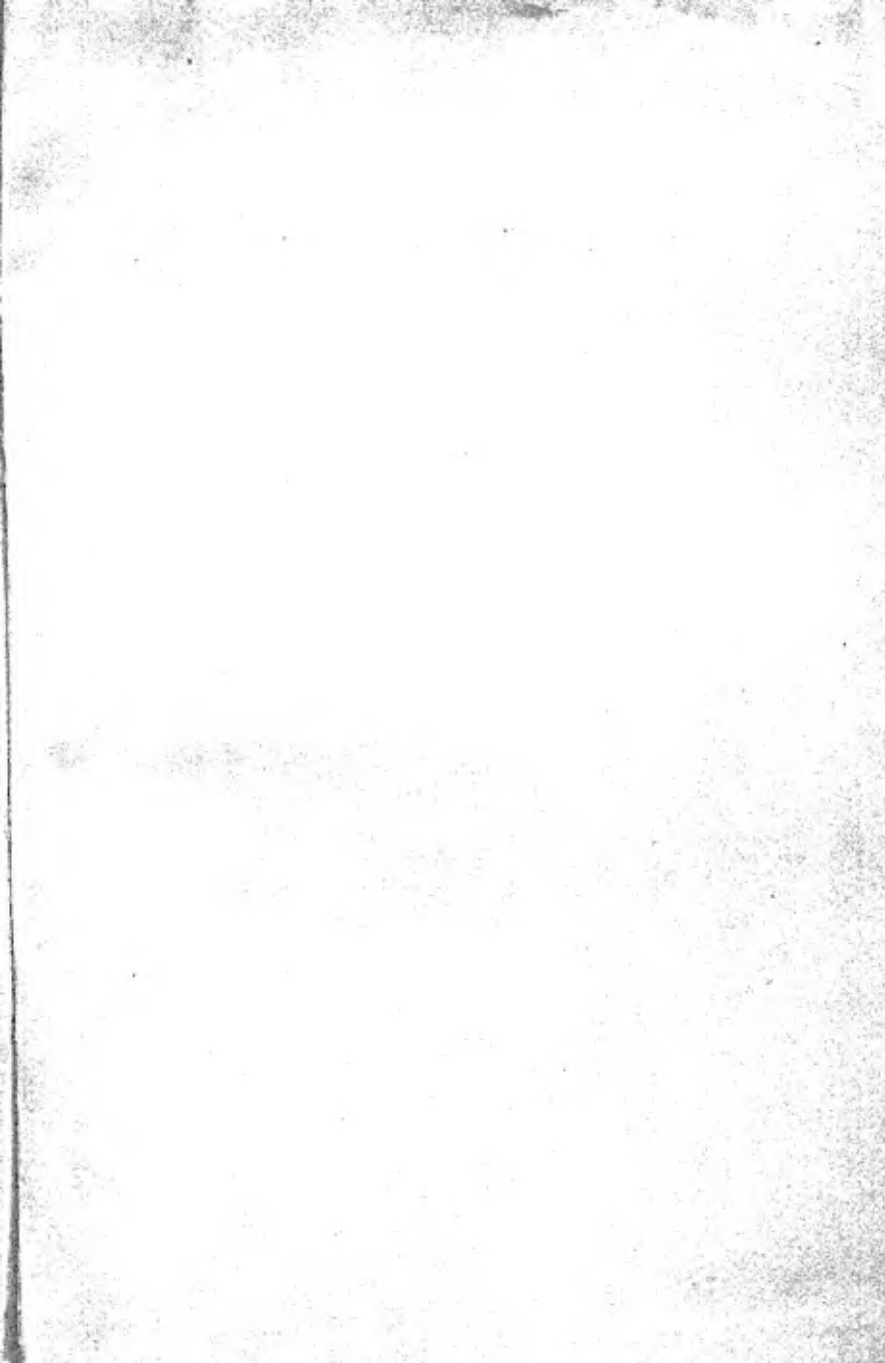
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